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Difficult Deep Foundation Work at the Hauserlake Dam, Montana.

By GEORGE A. McKAY.*

The Hauserlake power plant of the United Missouri River Power Co., located on the Missouri River about 18 miles below Helena, Mont., is one of the three large hydro-electric developments the company operates in this locality. The first plant at Hauserlake, opened in March, 1907, comprised a powerhouse of steel and masonry, containing five hydraulic and electric units of 1,000 HP. each, driven by water stored behind a large structural steel dam of triangular section.

This dam was 70 ft. high and 630 ft. long, and was built of steel bents, supporting curved steel plates forming the water face of the dam. Both ends of the dam were founded on solid bed rock, but about 400 ft. of the center section was on a gravel foundation. The dam was anchored at the upstream toe to steel sheet-piling driven in the hard river ground.† On April 14, 1908, the water managed to penetrate under the foundations of the dam and, ripping out the underlying gravel and protecting sheeting, caused the complete failure of the dam and consequently the power plant.

The design of a new plant was immediately started. This design used the same location for the dam and included the same powerhouse, but provided a solid concrete dam of the ogee type with a spillway extending over most of its length. It is 670 ft. long from the head-race canal on the east side of the river to the west abutment, and the crest is 49 ft. high above tailwater, 61 ft. high above the foot of the ogee curve, and, as finally constructed, about 111 ft. high above the lowest point of the foundation. It contains about 88,000 cu. yds. of concrete. The present development consists of five 2,800-KW. units capable of producing 16,000 HP. under an effective head of 66 ft. On this new design work was started in July, 1908, and the waste gates on the completed dam were closed May 17, 1911. By May 21, 1911, the pond was filled and water was flowing over the crest.

The contract for the construction of the plant was let to the Stone & Webster Engineering Corporation of Boston, Mass., and they carried out all of the work with the exception of some extremely difficult foundation work which was let to The Foundation Co. It is the purpose of this article to describe this difficult foundation work.

Preliminary Foundation Work.

Inasmuch as the failure of the old dam was probably due to the undermining of the section founded on gravel, it was decided to build the new dam clear down to bedrock all across the river, instead of only on the sides. But in the center of the channel near the west abutment, rock is about 60 ft. below water level and is overlaid with a bed of wash-gravel and sand containing many large flint boulders. In the deeper pockets there is also a tough blue clay overlying the rock. The Missouri River here is likely to reach a flow of about 26,000 sec.-ft. during May, June and July, when the snow in the mountains is melting. Under these conditions, it was considered impracticable to construct a cofferdam immediately surrounding the work, and the following plan was applied:

A wooden flume 50 ft. wide and 1,565 ft. long, designed to carry a flow of 11,000 sec.-ft., was built on the west side of the channel. The river was turned into the flume by a diversion dam built across the river about 300 ft. above the line of the power dam. This diversion dam consisted of a line of steel sheet-piling driven to ledge rock and backed with a fill of gravel and rock. About 800 ft. below the main dam another line of steel sheet-piling was driven to hold the back water, and the entire area between these two lines of steel sheeting was pumped out. A general view of the site reproduced herewith as Fig. 1 shows the arrangement of this great cofferdam, but at a later stage, when it had been superseded by the caisson work described further on.

FIG. 1. GENERAL VIEW OF THE HAUSERLAKE DAM SITE AND CONSTRUCTION PLANT FOR NEW DAM.

(July 25, 1910. Note breached upper diversion dam, bypass flume, and jetty protecting the caisson work. At this time the timber flume where passing over the dam site had been replaced by a narrower concrete section and caissons were being sunk to enclose the foundation pit.)

The amount of water to be handled was very large, twelve to fifteen 12-in. pumps being required to keep the water down. Leakage through the upper diversion dam was considerable, as some of the sheeting did not reach to the ledge. Therefore, as bed rock was uncovered, the concreting was started along the back (upstream) line of the dam, and the concrete here carried up in advance of the rest of the foundation, to form a cut-off wall extending across the river and in this way reduce the amount of water to be handled. The foundation concrete thus was built up in a series of steps rising toward the upstream face of the dam, the highest step acting as protecting bulkhead.

Under this method work was progressing rapidly from the powerhouse or east side of the dam, where the footings reached rock at a comparatively shallow depth, and the upper or main section of the dam there was being carried to completion. Meanwhile, however, it was found impossible to keep the deeper part of the west section dry, and concrete was laid there only at the upstream edge, which was at a higher elevation. In the early part of April, 1910, the river began to rise, a month earlier than usual. When it reached a volume of 12,000 sec.-ft., the

*The Foundation Co., 115 Broadway, New York City.

†A descriptive article on the old Hauserlake dam appeared in Engineering News, Nov. 14, 1907, p. 507; an account of its failure, April 30, 1908, p. 491.

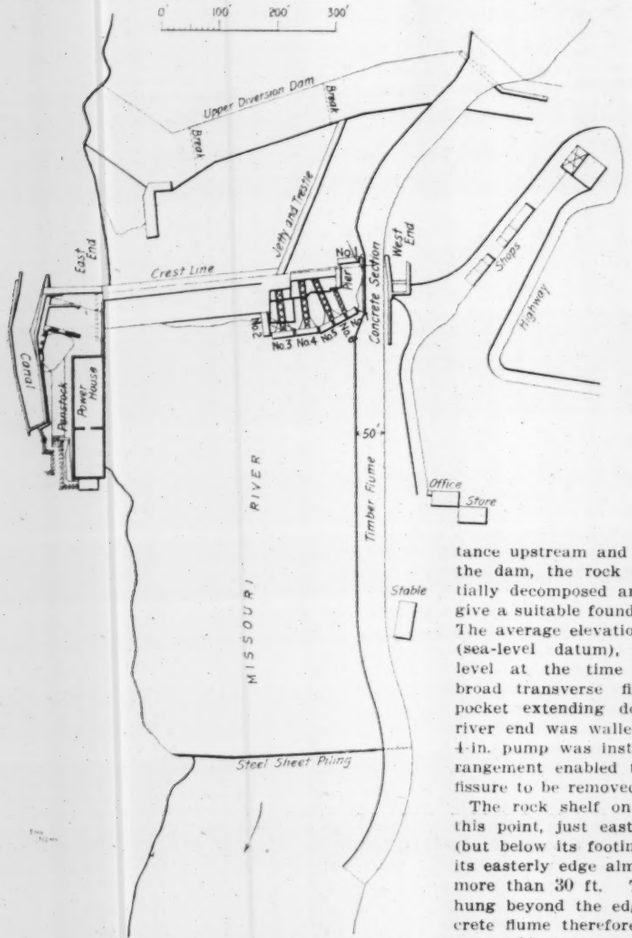


FIG. 2. GENERAL PLAN OF HAUSERLAKE DAM, SHOWING LOCATION OF DEEP FOUNDATION WORK AND CAISSON COFFERDAM SURROUNDING IT.

water ran over the edge of the flume into the excavation. Rather than lose the flume, which had already broken twice, it was decided to cut the upper diversion dam, and this was done on April 30, 1910.

The river continued high during the entire month of May and nothing could be done either in excavating or in placing concrete during this month. It was at this time that the decision was reached to resort to some other system of construction. The number of fissures in the rock was so great that it was recognized that it would be practically impossible to keep the lower section of the foundation dry enough to lay the concrete there. In any event the redriving of the steel sheeting in the two diversion dams involved extensive difficulty and expense. In this emergency The Foundation Co. was called in to undertake the foundation work up to a certain elevation—above high water—where the regular contractor could carry on the work as designed. All the time that The Foundation Co. was working on this particular job the main contractor was working alongside on the completion of that portion of the dam for which the footings had been placed.

Deep Foundation Work.

This work was started June 10, 1910. It consisted of sinking rectangular pneumatic caissons to bedrock, immediately around the deep hole in the channel, connected tightly together and to that portion of the structure already completed, so as to form a cofferdam that could be pumped dry. Fig. 2 shows the general layout of the work and the surrounding plant; a larger drawing of the caisson layout is given in Fig. 4, in which are noted also the locations and top elevations of the various masses of concrete which were in place when the plan was decided upon.

CONCRETE FLUME SECTION.—An important feature of the plan was the replacement of the section of the wooden flume passing through the line of the dam by a concrete section, partly because this flume was on a precarious foundation and partly because it was in the way of the needed cofferdam. This was the first work undertaken by the subcontractor. On removal of the wooden flume the river face of the rock foundation under the old west abutment was uncovered, and thoroughly cleaned. The concrete placed here and in the flume was afterward incorporated in the finished dam.

The wooden flume being removed for some distance upstream and downstream of the faces of the dam, the rock under it proved to be partially decomposed and had to be cleaned off to give a suitable foundation for the concrete flume. The average elevation of rock here was El. 3572 (sea-level datum), slightly above the water level at the time this work was done. A broad transverse fissure, however, formed a pocket extending down some 6 ft. lower; its river end was walled off by a sack dam and a 4-in. pump was installed to drain it, which arrangement enabled the decomposed rock in the fissure to be removed.

The rock shelf on which the flume rested at this point, just east of the old west abutment (but below its footing elevation), dropped off at its easterly edge almost vertically to a depth of more than 30 ft. The timber flume had overhung beyond the edge of this shelf. The concrete flume therefore required to be made narrower, 34 ft. instead of 50 ft. wide, in order to obtain direct support. The bottom concrete was carried up to El. 3576, on a uniform grade with the wooden flume. The sides of the concrete flume were brought up in concrete walls 3 ft. thick to a height of 12 ft. above bottom and were tied together near the top with nine 1½-in. rods with turnbuckles to resist the outward water pressure. Provision was made at both ends of the concrete portion of the flume for connecting with the wooden flume, by leaving 12 × 12-in. sticks concreted in, in floor and sides, for fastening planks in making tight connections. Keys were left in both bottom and sides to afford bond when the balance of the dam here should be built. A large number of scrap pieces of structural shapes from the old steel dam was placed in the walls for reinforcement, and others, extending through the forms, for furnishing bond with later work. When the concrete section was completed, it was connected up by a gradually increasing wooden section to the old flume. The bottom and sides of the timber connection were thoroughly caulked and made ready for water.

While this work was being done, a pile jetty was built from the remains of the upper diversion dam to the westerly end of the completed or partly completed portion of the power dam, so as to divert the main part of the river flow into these wasteways and break the current at the points where the line of caissons was to be sunk. This jetty is shown in the plan Fig. 2, and may be seen in the view Fig. 6. Round piling, 40 ft. long, was used at the start, but as the depth increased near the dam the jetty was completed with 12 × 12-in. timber. The structure was amply stiffened by 12 × 12 in. walings through-bolted to the piles. A 24-in. track was laid along this jetty and was used for filling in between the lines of piles with broken rock. Two dinkey trains, each with eight 1½-yd. cars, were used for this fill. This jetty served admirably to produce quiet water for the caissons.

CAISSON CONSTRUCTION AND SINKING.—Oregon fir timber for building the caissons began to arrive July 1, 1910, and the framing of Caisson 1 (see plan Fig. 4), was started at once. The working chamber was assembled in position on cribbing, and when completed was lowered by means of jacks to the river bed. The caisson, which was placed just above the upstream line of the dam, was made long enough to span the gap between the ledge upon which the concrete flume was built, and a concrete pier at the westerly end of the portion of dam completed, which had been placed under the prior plan of working. (See plan Fig. 4 and elevation in Fig. 3). The caisson lapped this pier sufficiently to allow for a joint between the two.

Air was put on Caisson 1 on July 26, 1910. The material through which it was sunk was extremely refractory, being composed of packed gravel containing many huge flint boulders and detached blocks of reinforced concrete from the foundations of the old steel dam. One immense block of this concrete, reinforced with ⅞-in. rods, covered the entire pocket beneath the air shaft for a depth of 15 ft. Dynamite (60%) was used to break up the boulders and masses of concrete.

The working chambers of all the caissons were built without division into compartments, but were tied across by several rows of braces, the space between the rows of bracing timbers being called pockets. On the roof of the working chamber was built an enclosing box of wooden cribbing which was filled with concrete around the air shaft as the sinking progressed. The final level of top of concrete was approximately El. 3560, the foot of the ogee curve of the downstream face of the dam. The caisson cribs were carried some 15 ft. above this height, with gravel filling, these portions to be removed after completion of the dam foundations.

The Oregon fir used for the working chambers was so porous that it did not hold air well. In Caisson 1 the inside was covered with several coats of white lead to make the working chamber tight. All the working chambers built thereafter were thoroughly pitched before launching and gave no trouble.

The cutting edge of Caisson 1 struck rock at El. 3550.7 on the end towards the flume, but this was excavated and the cutting edge was carried to El. 3544.2, at which level good rock extended over the entire bottom. Before filling the working chamber with concrete, enough rock was removed to form an effective key throughout the entire length of the caisson.

While sinking through rock a weight platform was built on top of the crib, and gravel piled on this to overcome the skin friction.

The lower line of caissons was located so that it would come just outside of the toe of the completed dam. Caissons 7, 6, and 5 were placed at an angle with the dam, because the rock beneath them was not so deep as beneath Nos. 3 and 4 and the toe of the dam consequently receded up-stream. (See Fig. 4.) This arrangement also provided a good abutment for Caisson 7 against the ledge. One of the supporting cribs beneath the wooden flume had been sunk at the site of Caisson 7, and it was necessary to remove this, by use of divers, who sawed off the timbers and fastened derrick chains to them.

Caisson 7 was built on a launchway, launched and floated into position. Before landing, the bottom was excavated and leveled by an orange-peel dredge so as to afford a depth of about 20 ft. of water. Sacks filled with gravel were then used to afford a nearly level landing place for the cutting edge. Twelve location piles were driven and swaybraced to keep the caisson upright before landing on the river bed, while the cribbing timbers were being put in place and caulked. Guy-cables were also used to prevent overturning. As concrete was placed on the deck the buoyancy of the timber caissons was gradually overcome and the guys were evenly slacked off as concrete was added.

Several 12 × 12-in. timbers were encountered during the sinking of No. 7, timbers of the old crib which had been missed by the divers. These were removed from beneath the cutting edge by means of chisel bars. Rock was encountered at El. 3538, and the cutting edge was finally

stopped at El. 3529.7. Enough rock was removed over the entire bottom, as in No. 1, to form an effective key. Air drills as well as hand drills were used in removing rock. The average water level, during the sinking of all the caissons, was El. 3569.5. Caisson 7 was sunk in 25 days.

In sinking Caisson 6, it was also necessary to cut through five courses of the sunken crib. This caisson was carried to El. 3522.8 in 31 days after air was put on.

Caisson 5 had one skew end, and great care was necessary in handling and sinking it. This caisson was carried through the wreck of an old sunken barge, and through several logs about 16 ins. in diameter. At El. 3531.9 the cutting edge landed on a row of steel sheet-piling which, before the work had been flooded in April, had been used to enclose a section of the bottom. After trying several schemes for cutting off this steel with pneumatic rippers, etc., without good result, resort was had, probably for the first time in a caisson, to the use of an oxyacetylene flame. The gas was raised to a pressure sufficient to overcome the air pressure inside the working chamber, and the steel was removed without mishap. This sheeting was standing vertically, was 14 ft. long and extended to the rock. It was removed in vertical sections about 30 ins. long. To get the steel bare for burning, it was necessary to mud up the entire cutting edge, to sheet down beneath the shoe with plank along the steel and mud up along this wooden sheeting to hold the air. The gas was raised to the required pressure by use of a belt-driven pump ordinarily used for pumping oil to the governor of a waterwheel.

This caisson was carried at one end 3 ft. into rock, and was landed at El. 3517.5 in a total sinking time of 35 days.

In sinking Caisson 4, more steel was encountered. In this chamber it was lying flat, having evidently been overturned in the rush of water when the upper diversion dam had been cut. This steel was removed in the same way as in Caisson 5. The caisson was also carried through a nest of five lengths of 14-in. spiral riveted pipe, the discharge pipes from the pump scow in use the previous season. The cutting edge of this caisson was carried to El. 3513.63, or to a depth of 55.9 ft. below water level, one end being 3.9 ft. in rock. The sinking time was 40 days.

Caisson 3 was the only one sunk for the cofferdam whose shoe was not carried into the rock. In sinking, this caisson became hung up on the end of No. 4, and could not be carried farther, even with an extremely heavy load of gravel on the weight platform. It is now known that the rock rose nearly vertically at the outstream or east end of the working chamber, and that the sharp angle of this rock served to wedge the caisson against No. 4. When rock was reached after excavation below the cutting edge, the bottom was carefully cleaned off, a key excavated in one end, and 14 holes drilled in the other end for 1½-in. anchor bolts. The mass of concrete below the cutting edge was heavily reinforced by short pieces of structural steel. The deepest point of rock in the sinking was found on this bottom, being at El. 3510.5, or 59 ft. below water level. The cutting edge was left at El. 3514.6.

Caisson 2 was located at right angles to the line of the main dam, its end toward the dam being 2.5 ft. from the vertical concrete wall beneath the lip of the ogee. Its downstream end lapped Caisson 3. In sinking, the end towards the dam was carried through the concrete of the toe from El. 3544 to bedrock at El. 3525.7. This concrete was removed by light charges of dynamite in holes drilled by small air drills. In addition to the concrete encountered here, over 100 ft. of steel rails was cut through and taken up inside of the working chamber. These rails had been used in the serving track to a mixer plant set up here before the high water. At one time the cutting edge landed full on a vertical 12 × 12-in. timber, forming part of the platform around this mixer. Other timber which had to be removed was the forms and studding of the concrete toe. The average surface of rock was about 10 ft. higher beneath Caisson 2, than beneath No. 3. It rose up from the lower level in an almost vertical wall, and where No. 2 lapped No. 3, a pocket was carried down by sheeting and caulking with oakum and clay, to a point lower than the cutting edge of No. 3, and was filled with concrete reinforced with ¾-in. round rods.

In making the cofferdam tight, nine joints were necessary. Five of these joints, between Caissons 6 and 7, 5 and 6, 4 and 5, 3 and 4, also between Caisson 1 and the rock under the flume, were made by the pneumatic method. These joints were made by first bolting 12 × 12-in. timbers on the outside facing sides of adjoining caissons, before they were driven, forming the corners of a square which was utilized later as a shaft for the excavation of the material under

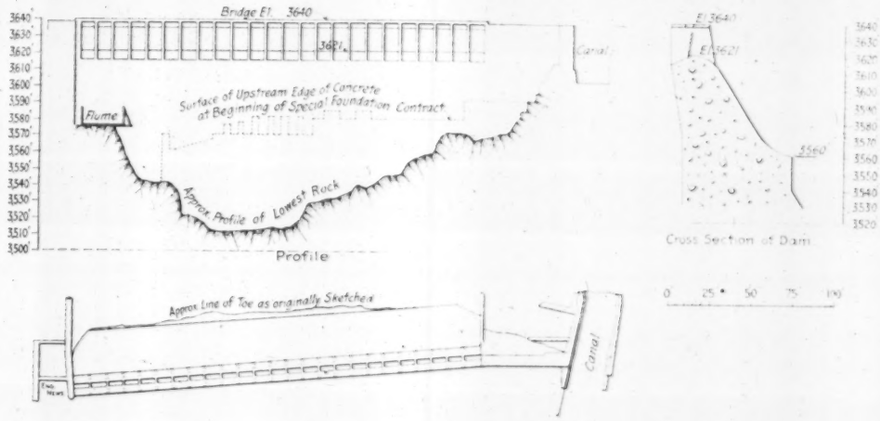
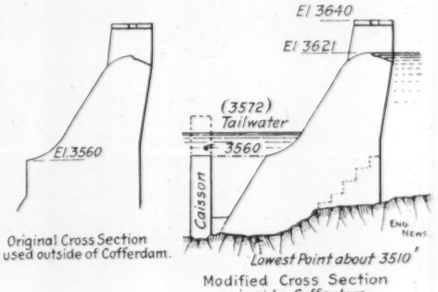


FIG. 3. PLAN AND SECTION OF HAUSERLAKE DAM, AND ROCK PROFILE ON LINE OF DAM.



air. When the caissons were down to their full depth a thick capping of concrete was put across the gravel intervening between the two caissons, with an open pipe projecting down into the gravel between the corner timbers noted. An airlock was then put on this pipe and the gravel below excavated under air, enclosing the excavation as it descended by planks spiked against the corner timbers. In each case all material was removed from between the ends of the cribs and working chambers down to the rock, concrete was packed into the space, and two 2-in. grout pipes were put in on bedrock and brought up through the concrete to above water level. These pipes were afterwards grouted; each required about 50 sacks of neat cement grout to seal. The grout was introduced through a small grout machine with 2-in. connections. The joints were each made in from seven to twelve days. After unwatering the cofferdam they proved to be very satisfactory, without exception.

The four other joints, between Caisson 1 and the end of the old work, between Caissons 2 and 3, between Caisson 2 and the finished part of the dam, and between Caisson 7 and the rock beneath the flume, were all made without the use of air. In the case of the first two, the material was removed to rock by using an orange-peel bucket. When this was accomplished, a diver was sent down to do the final cleaning of the bottom and to report on the contour of the rock exposed. A rectangular box form, of sufficient length to extend from the bottom to a few feet above water, was sunk in place and securely fastened by wire cables to the caissons to hold it in place. Enough concrete in sacks was then placed by a diver to cover the bottom and to seal off any unevenness of the rock. The balance of the concrete was placed through water in a bottom-dump bucket. As the concrete was added, gravel was again filled in behind the form to keep it from spreading out. Grout pipes, 2 ins. in diameter, were also left extending to the rock beneath these joints. These joints each required about 150 sacks of neat cement grout to seal, but they proved quite as satisfactory as the joints made by the pneumatic method.

The other two open joints required different treatment, on account of their considerably greater length. In each case most of the gravel alongside of the joints was removed by orange-peel dredging. A diver also worked, loosening up material at the end of the caissons so that this would run down into the deeper hole beside the joint where the dredge would reach it. When nearly all of the gravel had been removed in this way, two rows of interlocking sheet piling, built up of 12 × 12-in. timbers with white-pine splines, were driven to enclose the area between the ends of the caissons and the wall. The final excavating was done by diver inside of this sheeting. Concrete was placed between the rows of sheeting through water, and three grout pipes were left in each joint. On these joints the diver not only had to place the bottom concrete in sacks, but was also used continuously throughout the concreting to stop all leaks in the same way at the sides of the sheeting, to keep the concrete from wasting. In grouting, about 200 sacks of cement were used on each joint.

WORK IN THE COFFERDAM.—To get quiet water during the sinking of the caissons, and also to break the current so that the upstream cut-off wall of concrete, which was about 12 ft. below water surface, could be brought up to complete the cofferdam, the upper diversion dam was again rebuilt, by a rock fill, and most of the river flow was diverted through the flume. This work was done while Caisson 4 was being sunk, and was accomplished during a comparatively low stage of the river. Filling was carried on from both ends by dinkey trains, and the final gap was closed by sinking a pine tree mat weighted down by large stones. This was floated into place and weighted, by use of a floating derrick. While this rock fill did not stop all the water, the leakage was so small that the wasteways left in the east end of the dam easily carried the water which was not diverted through the flume.

By referring to Fig. 4, it will be seen that when work shut down in April, 1910, the upstream face wall of the dam west of the finished wasteways, ending in the pier against which Caisson 1 had been placed, was about 12 ft. below water level (water level being El. 3570). This wall and the pier had to be raised above water to form, with Caisson 1, the upstream side of the

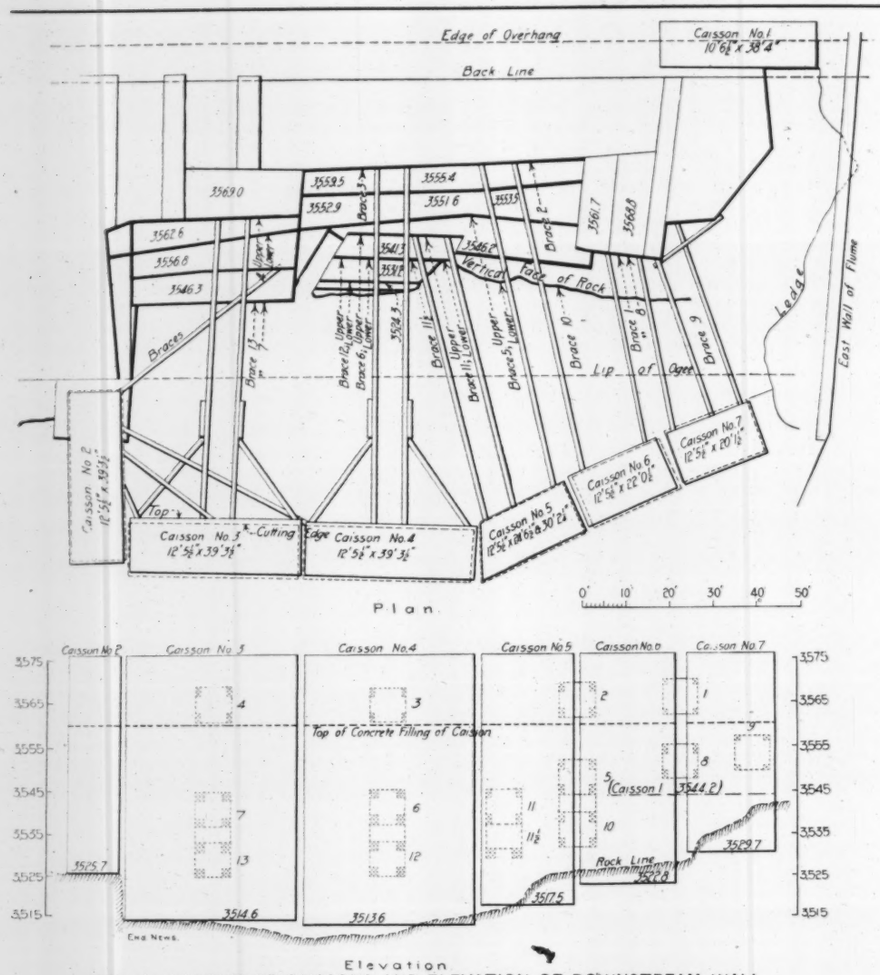


FIG. 4. LAYOUT OF CAISSONS AND ELEVATION OF DOWNSTREAM WALL.
(Figures in the plan give elevations of top of concrete in place before caisson work began.)

cofferdam. This was done by driving a double line of 3-in. sheeting on both sides of the wall, and puddling between them. On the lower side both lines of sheeting were driven to the old concrete through gravel which had washed over it during the overflowing of the work, and the puddle, which was of poor material, was put in in sacks, placed by diver. On the upper side the two lines of sheeting were driven just above the back line of the dam into the gravel wash against the concrete, and the space between the lines of sheeting filled with concrete deposited through water. When this concrete had set up the area was pumped out, and the leaks beneath the sheeting were caulked with oakum and sacks. The surface of the old concrete exposed was thoroughly roughened up; a large number of anchor rods were set in 1½-in. holes, and the concrete placed in the open.

The last step in making the main cofferdam tight was to close a 4 × 6-ft. waterway tunnel which passed through the concrete near the east end of the cofferdam. The tunnel had been used the season before to handle the leakage from the upper diversion dam through the concrete to the pumps below; it was at El. 3540, or 36 ft. below water level (since raising the upstream wall, the water had risen to El. 3576). A wooden gate, with rack and pinion to close the tunnel had been provided, but this gate had been left open when the diversion dam was cut. Gravel wash had filled the tunnel and buried the gate and closing mechanism. To close the gate, a stiff-leg derrick was erected and the gravel was dredged away with an orange-peel bucket above the gate, the dredging continuing until the tunnel opening was exposed. A diver had to do the final cleaning from the tunnel mouth, to remove the stone wedged in here. The closing apparatus was found to have been broken, either during dredging or in the rush of water and wreckage when the diversion dam had been cut, and could not be operated. A hood was therefore made to fit over a projection on top of the gate, and was attached to a vertical 12 × 12-in. timber which extended above water surface. The gate was then driven shut with a pile hammer, and a few yards of concrete were placed in front of the gate to seal any leaks. This work was done during a period of extreme cold weather, when for 12 days the thermometer never went higher than 6° F., and on three days went to 26° below zero. The diver's work during this time was very difficult.

In unwatering the cofferdam area, it was necessary to brace the lower line of caissons. This bracing is shown in the view Fig. 5. The lattice members were 3-in. plank, fastened to the 12 × 12-in. timbers of the chord members by boat spikes when first assembled and later bolted with ¾-in. bolts. The four upper braces were entirely assembled before placing, and were landed in the water in position by a derrick which had been erected on the small crib of Caisson 4. These braces were placed with their chords just above water level, and the ends were thoroughly wedged with large oak wedges acting against heavy oak reaction blocks. The lower chords were wedged similarly as soon as the water level had been lowered. In Fig. 4 the braces are numbered in the order in which they were placed.

HANDLING A LEAK.—The pumping was done by 12-in. centrifugal pumps which were connected on 18-ft. centers by belt to 150-HP. alternating-current motors. The tunnel gate was closed on Jan. 26, 1911. During that night two pumps lowered the water 15 ft., exposing bottom over two-thirds of the area of the cofferdam. Excavation with pick and shovel (wasting being by derrick in 1½-yd. skips), was started at once and pushed in the corner near Caisson 1 [illegible] the rock there was known to be the highest [illegible] This section proved to be a very difficult [illegible] Immense detached blocks of reinforced [illegible] crete from the foundations of the old dam [illegible] encountered. Fig. 7 shows one of these [illegible] ning over 70 cu. yds. and gives a good idea [illegible] the nature of the material through which Ca[illegible] 1 was sunk to rock. This view also shows [illegible] the right the shoulder of the ledge upon wh[illegible] the concrete flume was built, on the left the [illegible] at which the old work terminated, with for[illegible] still on, and in the background Caisson 1. [illegible] also shows water which came from a leak at [illegible] decomposed seam in the vertical face of th[illegible] ledge beneath the flume. As excavation proceed[illegible] the amount of water from this leak increased, and excavation was then started over the entire area of the cofferdam so as to drain the water from the corner.

It had been intended to clean off the rock over the entire section below Caisson 1, between pier and ledge, and to place this concrete in one block, but by the time rock was exposed at El. 3544 so much water was coming from the decomposed seam in the cliff that this was impracticable. At this time five 12-in. pumps were being used continuously and nearly all this water was coming from the one leak. So a block of concrete 20 ft. wide was first placed along the pier. The slight leakage from the joint between Caisson 1 and the pier was conducted through this block in a bleeder pipe (a length of 14-in. spiral riveted discharge pipe); a vertical length of 8-in. pipe was left as a standpipe, at the intake of the bleeder for later grouting. As soon as the forms could be removed from this concrete, another section of bedrock was prepared. This section extended from the first block along Caisson 1 to the cliff, and back almost to the point of the bad leak. Another drain pipe was left in this block to handle the slight leakage around that end of Caisson 1, with similar provisions for grouting.

These two blocks of concrete hemmed in the leak so it could be handled. A double row of 2-in. sheeting was driven around the front of the leak, and a facing of burlap sacks filled with concrete was laid along the sheeting. Through the sheeting was passed a drain pipe consisting of an 18-ft. section of 48-in. air shafting, used in sinking the caissons. The discharge end of the pipe was fitted with a hinged drop-door of plate iron, which swung up inside the pipe. The door had a gasketed bearing against a perforated diaphragm bolted over the pipe flange, and was held up by a rope passed back through the drain in a 2-in. pipe. The slight leaks between the sheeting and the pipe were calked with oakum and sacks. The surface of bedrock outside the enclosure being cleaned off, concreting was begun, the concrete being carried up around the drain pipe. When it reached the level of the top of the sheeting, the concrete was bridged over the enclosure and the end of the pipe by placing short 12-in. I-beams across for a roof. A 14-in. standpipe was left through an opening in this roof for later grouting. The concrete just above the I-beams was placed in burlap sacks. The whole block was then carried up to El. 3576, or well above water level outside the cofferdam.

It was thought that the leak was following a decomposed seam in the cliff and coming from the pool above the dam, but to provide for the possibility of its coming from the mountain, under high head, it was decided to wait two weeks before dropping the door, for the concrete above the 48-in. pipe to strengthen. During this time excavation was carried on for a section of the toe against Caisson 7, and concrete placed here. This block was carried up to completion, the ogee forms put in place and concreted. It was difficult to keep the sump holes for the pumps clear, as the swift currents in the cofferdam kept fine gravel running in around the strainers and clogging them. This made it difficult to do general excavation during the two weeks, as the water could not be kept low enough for the laborers to accomplish much. About this time a sudden rise in the river caused the rock fill in the upper diversion dam to break, but no damage was done, as the five wasteways in the east end

of the dam, together with the flume, carried off the storage in the pond without flooding the cofferdam or affecting the operations in any way. The river was passing about 6,000 sec. ft. at the time of the break.

Before closing the 48-in. pipe the pumps were lifted, allowing the water in the cofferdam to rise to El. 355, or about 12 ft. above the open end of the pipe. The rope holding the door was cut and the door dropped. All flow stopped at once. The 14-in. standpipe left for grouting was extended and fitted with a hopper, and neat cement grout mixed in the concrete mixers was poured down this pipe. The hopper was high enough to afford a static head of 76 ft.; 5,325 sacks of cement were put in in this way, when a return of grout was detected in the water below Caisson 7. Grouting was then discontinued, and one more day allowed for the grout to set up. The cofferdam was then again pumped out, with a single 12-in. pump, and excavation resumed. From this time on the pumping was much simplified, one pump serving at all times to handle the slight leaks through the joints and cribs.

The uncovering and final concreting of the balance of the bottom offered few difficulties in comparison with the leak already handled. In order that the concreting might progress at the same time as the excavation, whenever a fair patch of bed rock was exposed and prepared, it was concreted. In placing these blocks, care was used to have all joints in a plane at right angles to the line of the dam and never parallel to it, and the joints were amply provided with keyways and projecting pieces of scrap structural steel for bond. Whenever water from the joints or from springs in the rock had to be handled in placing concrete, drain pipe were laid of sufficient size to handle the leaks, and the water diverted into these pipes by sack dams made of burlap sacks filled with concrete. This prevented washing of the concrete and proved a very satisfactory way of handling the problem.

The lowest point of rock uncovered was El. 3510.7. In uncovering some of the lowest sections of the rock, sack dams or lines of sheet piling were used to enclose the section and a 6-in. submerged pump was put in the enclosure. This type of pump would take air without losing its prime and was very useful in lifting water a short distance to the higher sump of the 12-in. pump. As has been noted, one 12-in. pump handled all water from the dam even when the lift became as high as 62 ft. This pump was run at about 650 r. p. m., and would have been ample at a lower speed than this.

The bed rock was an extremely hard quartzite. It was always found uneven, often waterworn, with ridges and pockets which afforded a satisfactory bond without resorting to any artificial means. Inside the cofferdam area the toe was extended out to the line of caissons and carried up against these to El. 3522, where the batter face wall was started.

BRACES IN COFFERDAM.—The lower braces were placed one chord at a time, and were placed in trenches carried down ahead of the general excavation. Each chord was wedged into place, and did partial duty until the excavation could be carried down enough to allow the next lower chord to be placed and latticed to it. In this way little time was lost, and the cofferdam was kept intact and in perfect condition at all times.

The lateral braces were all removed before the concrete was placed. To enable the lower chords of the braces against Caissons 3 and 4 to be removed, concrete piers 6 ft. wide bearing against the caissons were carried up to El. 3536 on each side of these braces. The chords were removed one at a time. They were sawed off so that about 2 ft. of the upstream ends would extend into the concrete of the face. From the face to the caissons the braces were left in place to protect the cofferdam. Before removing the top braces at Nos. 3 and 4, two short 24 × 24-in. pusher braces were placed against each of the two caissons, reacting against the concrete face at a point about 6 ft. below the lip of the ogee.

When the concrete was all above water and the ogee curve completed, the caisson cribs were removed down to the concrete filling of the caissons, El. 3560, or to a level with the lip of the ogee. The inner sides of the crib walls were first torn out and most of the gravel filling removed. The outer sides were later blasted away.

When the concrete work was finished, work on finally sealing the seam where the 48-in. drain had been put in, was resumed. Instead of pouring in more neat cement grout, screened sand mixed with cinders was introduced into the standpipe. Air pressure of about 30 lbs. was then put on to force this charge back in an attempt to plug the opening which had been discovered below Caisson 7, where the grout had been running out. These cinders and sand were put in in small quantities, and were followed up with a small batch of grout. Air pressure was put on after each batch. When work was resumed on the second day, the downstream opening was found to be plugged, but a return of air was detected about 50 ft. upstream above Caisson 1. The same method of procedure was used for three days more, when the return of air ceased above the dam. At that time it took three hours for a pressure of 30 lbs. in the standpipe to drop to 5 lbs. Nothing was then done for a week. When operations were again taken up, a pressure of 100 lbs. failed to give a return of air above the dam, and it was impossible to introduce any more grout. During these operations about 8 cu. yds. of sand and cinders had been used and 120 sacks of cement. The standpipe was then filled with concrete.

Further operations were carried on with no especial difficulty, and the work was carried to a successful completion in the spring of this year, and, as noted above, the whole plant was put in operation on May 21, 1911.

Mr. M. H. Gerry is Chief Engineer and General Manager of the United Missouri River Power Co., Mr. G. O. Muhlfeld is Construction Manager for the Stone & Webster Engineering Corporation whose Superintendent on this work was J. H. Hood, and Mr. W. L. Christie was the superintendent in charge of the above described work for The Foundation Co.

FIG. 5. VIEW LOOKING DOWN INTO FOUNDATION PIT, SHOWING BRACING OF CAISSON COFFERDAM WALL.

FIG. 6. JETTY AND SECOND UPPER DIVERSION DAM UNDER CONSTRUCTION.

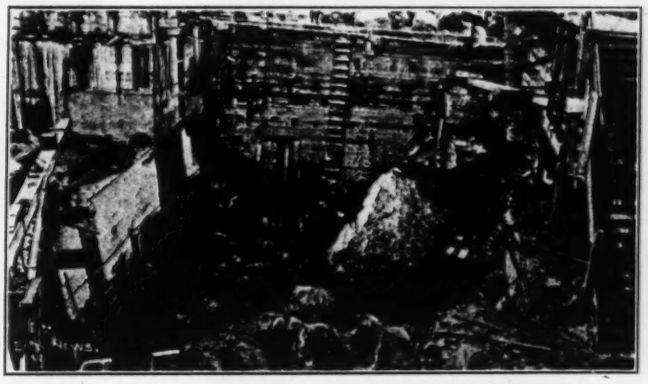


FIG. 7. VIEW INTO WEST END OF FOUNDATION PIT; CAISSON 1 IN BACKGROUND, FLUME ON TOP OF LEDGE AT RIGHT.

THE INSPECTION AND ANALYSIS OF PUBLIC water supplies in Illinois are to be conducted on an extensive scale hereafter, in accordance with recent new state legislation, the substance of which is as follows:

That the State Water Survey, heretofore established at the University of Illinois, shall in addition to the duties heretofore imposed upon it, be authorized and instructed to employ such field men as may be necessary to visit municipal water supplies and inspect water sheds to make such field studies and to collect such samples as are necessary, to analyze and test samples and to make any investigations to the end that a pure and adequate public water supply for domestic and manufacturing purposes may be maintained in each municipality, to make sanitary analysis free of charge of samples of water from municipal water supplies or from private wells collected according to the directions of the State Water Survey, and to report the result of such examination to the Board of Health, Superintendent of Water Works, other officer or officers of the Water Department of the city, village or incorporated town or to citizens by whom the samples, respectively, were collected.

A sum of $15,000 has been appropriated to carry on the work indicated above

for making any investigations that will show how to best obtain or conserve an adequate supply of pure water for domestic and manufacturing purposes in every section of the state.

The Survey is to publish an annual report and such special reports as may be necessary in connection with this work. We are informed by Prof. Edward Bartow, Director State Water Survey, Urbana, Ill., that the field work outlined above will be under the control of a competent sanitary engineer and that field inspectors and additional laboratory men will be employed to carry on the work.

Five Months' Work on Tunnel 10-A, Little Lake Division, of the Los Angeles Aqueduct.

By CHARLES H. RICHARDS.*

A particularly consistent piece of tunnel driving was accomplished in the five months Dec., 1910, to April, 1911, incl., in the South Heading of Tunnel No. 10-A, Little Lake Division, Los Angeles Aqueduct, William Mulholland, Chief Engineer; J. B. Lippincott, Assistant Chief Engineer; John C. Sells, Foreman; and the writer, Engineer in Charge of the Division.

The section of tunnel to excavate is about 9 × 10 ft., and approximates 3.25 cu. yds. per lin. ft. The material driven through ranged from a moderately hard close-grained to a quite hard massive coarse-grained granite, with small strata of a soft disintegrated granite carrying water to an appreciable extent.

On Dec. 1, 1910, the breast was 700 ft. in from the portal, and the dump was out 200 ft., making a haul of 900 ft.; while on April 30, 1911, the heading had been advanced to 1,945 ft. from the portal, with the dump extended to 400 ft., making a haul of 2,345 ft., an average haul for the five months of 1,622 ft.

The work was accomplished by one standard bonus crew, which consisted of eleven men, including the foreman, paid daily rates as follows:

1 foreman	$4.00
4 miners	3.00
5 muckers	2.50
1 mule driver	2.50

This crew was entitled to a bonus fixed by local conditions. In this particular tunnel the base rate is 3.00 ft. per shift for untimbered ground, and 2.30 ft. per shift for timbered ground. Each man in the crew was entitled to 30 cts. per foot of advance over the base rate. The average bonus made per man per day for the five months was:

8.40 ft. − 3.00 = 5.40 ft. × 30 cts./ft. = $1.62,

thereby bringing the daily wages up to:

Muckers	$4.12
Miners	4.62
Foreman	5.62

no distinction being made in the payment of bonus, all sharing alike.

The outside crew which did not participate in the bonus comprised the following:

1 compressor man	$3.50
1 blacksmith	4.00
1 blacksmith helper	2.75
1 track and dump man	2.25

For three months the shift was arranged as shown below:

4 machine men	7 a. m. to 3 p. m.
5 muckers and 1 mule driver	6 p. m. to 2 a. m.

At the end of this period the muck could not be cleaned up during one shift, so the following arrangement of crew was made:

4 machine men	7 a. m. to 3 p. m.
4 muckers	4 p. m. to 12 p. m.
2 muckers	12 p. m. to 8 a. m.

By this arrangement the 4 p. m. to 12 p. m. mucking crew removed the major portion of the spoil.

Drilling was done by two No. 7 Leyner water drills mounted on a single screw horizontal bar, which is first set up to drill the top holes, and then lowered for the bottom cuts and lifters. The holes, 11 to 17 in number, of depths varying from 8½ to 10½ ft., were drilled in from four to six hours by these machines with an air pressure of 100 lbs.

The powder used was Hercules ammonia dynamite, 25% to 60%. From 18 to 22 lbs. per foot of tunnel was exploded, or an average consumption of 6.10 lbs. per cu. yd., place measurement. The cut holes were sprung with 60% powder, then loaded and shot until the holes "broke bottom," after which the side, top and bottom holes were shot. Waterproof fuse and a very strong detonator were used to explode the charges.

Before shooting, the bottom of the tunnel was covered for a distance of 30 ft. from the face with "muck sheets," which were ¼-in. steel plates 5 ft. × 10 ft. They greatly facilitated the removal of the spoil. The spoil was handled by the use of No. 3 square-pointed D-handled shovels and loaded into 32-cu. ft. rocker side-dump cars running on a single track of 25-lb. rail.

Ventilation was had by a No. 3 Root cycloidal blower, discharging through 12-in. riveted steel pipe. Immediately after shooting, the blower was operated in the direction by which it obtained its suction from the tunnel for about ten minutes, the end of the pipe being about 15 [illegible] from the breast. The blower was then reversed, discharging fresh air into the heading. By this operation the men go into the heading [illegible] minutes after shooting.

The most striking feature of the driving of this tunnel was the small amount of equipment used—three drilling machines having been found sufficient to carry on the work, two in use and one in reserve. Only two cars were in use during the five-months' run. Particular attention was paid to the upkeep of this equipment, with the result that a very efficient condition was maintained. This condition does not usually obtain where bonus for speed only is being paid.

Tables I. to IV., herewith, give a tabulation of the progress, cost, powder used, and other details.

TABLES I.-IV.—PROGRESS, POWDER CONSUMPTION AND COSTS.

For Five Months' Work on Tunnel 10-A, Little Lake Division, Los Angeles Aqueduct.

TABLE I.—PROGRESS OF EXCAVATION.

Month.	Progress, lin. ft.	Actual number days worked.	Average daily progress, ft.
December	234	30	7.80
January	235	30	7.83
February	236	27	8.08
March	276	31	8.90
April	263	30	8.76
Total	1,244	148	8.40

TABLE II.—POWDER CONSUMPTION.

Month.	Pounds of powder of different grades. 25%.	40%.	60%.	Total per lin. ft.
December	...	3,750	800	19.438
January	...	4,550	400	21.064
February	...	4,100	300	18.640
March	...	4,275	700	18.025
April	500	3,950	1,300	21.862
Totals	500	20,625	3,500	19.795

TABLE III.—COST OF DRILL REPAIRS.

	Total.	Per lin. ft.
December	$71.85	$0.307
January	83.17	0.353
February	55.00	0.233
March	39.80	0.144
April	41.64	0.158
Totals	$291.46	$0.234

TABLE IV.—COST OF TUNNEL DRIVING.

		Labor.	Live stock.	Material.	Electrical Energy.	Freight.	Total.	Excavation cost per lin. ft.
Dec.	Excavation	$1,705.89	$37.80	$691.04	$267.75	$142.17	$2,844.65	$12.16
	Engineering	47.13	13.30	.....	.....	.....	60.43	
		$1,753.02	$51.10	$691.04	$267.75	$142.17	$2,905.08	
Jan.	Excavation	$1,808.20	$67.50	$757.25	$253.12	$167.66	$3,053.73	$12.99
	Engineering	37.85	9.20	.....	.....	.....	47.05	
		$1,846.05	$76.70	$757.25	$253.12	$167.66	$3,100.78	
Feb.	Excavation	$1,933.21	$67.25	$669.32	$205.45	$146.64	$3,021.87	$12.80
	Engineering	47.19	10.35	.....	.....	.....	57.54	
		$1,980.40	$77.60	$669.32	$205.45	$146.64	$3,079.41	
Mar.	Excavation	$2,332.49	$67.30	$724.63	$236.83	$148.25	$3,509.50	$12.72
	Engineering	28.00	6.28	.....	.....	.....	34.28	
		$2,360.49	$73.58	$724.63	$236.83	$148.25	$3,543.78	
Apr.	Excavation	$2,191.49	$64.80	$699.57	$260.39	$139.90	$3,356.15	$12.76
	Engineering	33.74	11.05	.....	.....	.....	44.79	
		$2,225.23	$75.85	$699.57	$260.39	$139.90	$3,400.94	
Totals		$10,165.19	$354.83	$3,541.81	$1,223.54	$744.62	$16,029.99	$12.89

RECAPITULATION OF EXCAVATION COST:

	Total.	Per ft.
Labor—Wages	$7,757.33	$6.24
Labor—Bonus	2,407.86	1.93
Live stock	354.83	.29
Material	3,541.81	2.85
Freight and handling	744.62	.60
Electric energy	1,223.54	.98
Totals	$16,029.99	$12.89

*Engineer in charge of Little Lake Division, Los Angeles Aqueduct, Narka, Cal.

Auxiliary Oil Firing in Steam Boiler Plants.*

By H. A. WAGNER,† M. Am. Inst. E. E.

In presenting this paper I hope to give some insights with the use of fuel oil which will be of interest to all central stations, but particularly to those hydro-electric developments requiring auxiliary or standby steam plants. I am aware that a great deal of information has been obtained and is available on the use of fuel oil for boiler operation, and that many tests have shown that oil is too expensive for such use except when the price of coal is very high. It is not my intention, however, to recommend the use of oil to displace coal as a fuel, but merely to supplement coal to increase boiler output and to provide means quickly to supply steam for sudden increases of load.

With the rapid strides which we have made in the last ten years in decreasing the cost of producing electric energy, we have reached a point in steam-plant operation where the cost of interest and depreciation on our power-plant investment equals or even exceeds the operating cost of producing current. Consequently we must now look to means for reducing our investment as the most feasible way of further decreasing our cost of power. The most natural way of decreasing unit investment is to get more out of our investment. It is my belief that for peak loads and for emergency service we should get the maximum possible output from all our apparatus consistent with safety. In this paper I propose to describe one way of getting a largely increased output from the steam boilers.

It is well known that the capacity of the modern water-tube boiler depends, within fairly wide limits, upon the amount of fuel which can be burned per hour in the furnace under it. Several plans have been proposed and used to increase the furnace grate area so that more fuel can be burned.

The only practical plan for doing this with coal fuel necessitates firing the boiler from both ends, and requires increased space for this purpose and additional devices for coal handling, etc. Almost all electric loads with which we are familiar have well-defined peaks of comparatively short duration. Our apparatus is, therefore, only called upon for its greatest output at infrequent intervals.

These considerations led me to experiment with fuel oil for supplementing the coal fires and getting the desired increased boiler output. These experiments were made in the Westport Station of the Consolidated Gas-Electric Light & Power Co., of Baltimore.

DESCRIPTION OF INSTALLATION.—After trying several settings the furnace arrangement shown in Fig. 1 was finally adopted. The results obtained from this arrangement were so satisfactory that it was decided to equip the entire boiler plant in this way. As will be seen from Fig. 1, the space under the boiler back of the usual coal grate is made into a large combustion chamber with the oil burners at the extreme rear end. This combustion chamber is separated from the boiler tubes above it by tiling and from the coal grate by a low bridge wall. The bottom of the chamber extends from the burner in a gradual curve to the top of the bridge wall. The hot gases from the burning oil pass over the coal grate and upward through the first pass in the usual three-pass Babcock & Wilcox setting. Ample air inlets are provided around the burners and also in the side of the combustion chamber. Each furnace is provided with four oil burners. The coal grates are 14 ft. wide and 8 ft. long. The boilers are a standard type, 24 sections wide and 13 tubes high, rated at 650 HP.

The oil is delivered to the burners under 20 lbs. constant pressure and is atomized in each burner by a steam jet. The steam required for this purpose is under 1% of the amount generated by the boiler. By this arrangement either oil or coal or both together may be used to fire the boiler. It will be seen that the changes from the ordinary boiler setting are very slight and require no

*From a paper before the annual convention of the National Electric Light Association, New York City, June 1.

†Baltimore Gas-Electric Light & Power Co., Baltimore, Md.

additional space. One of the four burners in each furnace is used as a pilot and for the equivalent of a banked coal fire for keeping the boiler ready to steam. These pilot or banking burners are operated from a separate oil line, so that a single valve in the main oil line can be used to turn oil into any number of furnaces desired, thus putting any number of banked boilers into commission instantly.

In our Baltimore installation we have oil-tank capacity for 200,000 gals. From these tanks the oil is pumped by automatically controlled, motor-driven, pumps to the boiler furnaces. The pump control is such as to keep a constant pressure in the pipe system. The general arrangement of piping is shown diagrammatically in Fig. 2. In this diagram master valves (1) and (2)

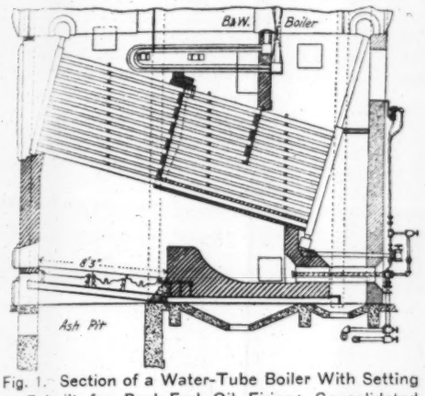


Fig. 1. Section of a Water-Tube Boiler With Setting Rebuilt for Back-End Oil Firing; Consolidated Gas-Electric Light & Power Co., Baltimore.

each control the pilot or banking burners for a group of five boilers. In like manner master valves (3) and (4) control the remaining burners in each group of five boilers. In operation let us assume that the five boilers, A, are being coal-fired for usual load, and that boilers B are banked with oil. Valves (1) (3) and (4) will then be closed and valve (2) will be open for banking boilers B. If a sudden increase of load occurs the opening of valve (4) upon signal from the switchboard will instantly put the five boilers, B, into service.

Still greater capacity could also be obtained by opening the valves (3) and (1), to operate boilers A with both coal and oil. In addition to the master valves shown, there are, of course, valves for controlling each burner and the group of burners for each boiler.

RESULTS IN ACTUAL OPERATION.—Ordinary boiler tests with the described arrangement have shown approximately the following results for maximum boiler output for seven-hour runs:

Coal alone	1,188 HP.
Oil alone	702 "
Coal and oil together	1,445 "
Coal and oil maximum hour	1,632 "

Under actual operating conditions, however, the gain by the use of oil is more marked.

It has been found that 2,000 KW. of station load can be carried by each boiler when using coal and oil together, with as much ease and certainty as 1,200 KW. per boiler can be carried by coal alone.

This shows, under operating conditions a gain in capacity of 66⅔% by the use of oil, or a saving of 40% in the cost of boiler plant for a given capacity.

It is under emergency or peak-load condition, however, that the advantages of fuel oil must be considered, and the durations of load under such conditions are usually too short for any comparisons by the usual boiler-test methods. Tests were made, therefore, under regular operating conditions to determine the minimum number of boilers which could be used to carry actual peak loads. The best record ever obtained in past operation of the Baltimore company's Westport Station with coal was 16,888 KW. (hour's average by integrating wattmeters) carried on 11 boilers. This is equivalent to 1,535 KW. per boiler.

The same station, operating in conjunction with a hydro-electric power-transmission line, recently carried a load of 11,100 KW. for two hours (two hours average by integrating wattmeter) with four boilers fired with coal and oil. This is a load of 2,775 KW. per boiler of 650 HP. rating. This is 80% increase of capacity by the use of oil as compared with the highest load possible with coal alone. The foregoing results show the great advantages of oil used to supplement coal, from the boiler investment standpoint. But the actual cost of operating peak and emergency loads in this way has proved to be much less than with coal alone. By decreasing the boiler capacity required by at least 40% the boiler-room labor is cut down in almost the same proportion, and not only for the short-peak periods, but for the time of one whole labor shift each and every day in the year. It must be borne in mind that winter or summer the average central station has a peak every day which is usually far in excess of the average day load.

So far we have not considered the greatest advantage of oil fuel, which is entirely aside from relative cost, namely, the ability with its use to take care of very sudden and unlooked-for increases of load without extra men or banked boilers carried for such emergencies. The output of any boiler, or all boilers, in use can be increased over 60% almost instantaneously by the opening of one master valve. Banked boilers can be brought up to full capacity within less than three minutes with oil, where at least 12 minutes would be required with coal under the very best conditions.

Actual tests have shown that a perfectly cold furnace, with water in the boiler at feed-water temperature, 142° F., could be made to steam at 175 lbs. pressure in 25 minutes with oil fuel as compared with 42 minutes with coal.

BANKING BOILERS WITH OIL FUEL.—It has been found that one of the four burners of the setting described, which I have called the "pilot" or "banking" burner, will, when not turned on full, keep up full steam pressure with the boiler stop-valve closed, thus taking the place of a banked fire. The cost of oil is 43% more than coal, per heat unit, under Baltimore conditions. In spite of this difference in cost of fuel, the actual cost of "banking" is less with oil than with coal, for the reason that the oil is burned efficiently while the coal is necessarily burned very inefficiently. We found: to maintain 175 lbs. steam pressure with boiler stop-valve closed;

With coal.....182.5 lbs. per hour, cost 21 cts.
With oil..... 56.17 lbs. per hour, cost 18 cts.

Our experience in this particular has led us to adopt oil for "banking" all boilers. We also find that it is unnecessary to keep boilers held for peak "banked" for the balance of each twenty-four hours, as is the general practice with coal.

FOR ORDINARY PEAK-LOADS.—It has already been shown that a saving in investment and in labor for peak load can be effected by the use of oil. To show just what this may mean in the reduction of operating costs I have applied the results obtained with the use of oil for peak loads, to the actual operating conditions and load-curves of an existing plant for the period of one year. This plant produced about 60,000,000 KW.-hrs. during the year, with a yearly load-factor of about 34%. On peak load 13 650-HP. boilers were used and required.

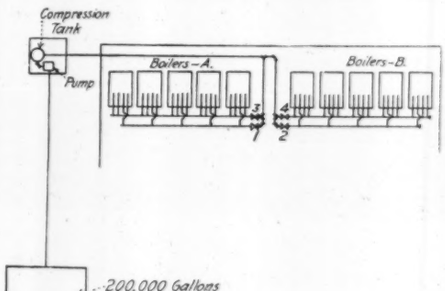


Fig. 2. Diagram of Oil Piping for Auxiliary Firing at the Westport Station, Baltimore.

The load-curves show that with oil used on the peaks to supplement coal, seven, or at the most eight, boilers would be required. From cost-curves prepared for each month for both coal and oil conditions, the total cost of fuel and labor with coal was shown to be 3.59 mills per KW.-hr., and with coal supplemented by oil 3.28 mills per KW.-hr. The saving with oil on the total cost of fuel and labor would, therefore, be 0.31-mill per KW.-hr., or 8.6%. No maintenance nor fixed charges are included in the above figures.

Assuming the cost of complete boiler plant to be $20 per KW. and the fixed cost (interest, depreciation, taxes and insurance) to be 15%; the fixed cost per year for the boiler plant would be $3 per KW.-hr. Again, assuming a yearly load-factor of 34%, equivalent to 3,000 hours' use per year of the maximum load, the fixed cost per KW.-hr. would be 1.0 mill. The use of oil as described will save 40% of this, or 0.4-mill. This added to the saving in fuel and labor makes a total saving of 0.71-mill per KW.-hr. Assuming a total switchboard cost, under coal conditions, of 4.2 mills per KW.-hr., this reduction is equivalent to saving 17% on the cost of generating current. Surely such a saving is worth considering when the means are so simple.

EXPERIENCE IN A STEAM-PLANT STANDBY OF A 40-MILE TRANSMISSION LINE.—Fuel oil shows its advantages as compared with coal most markedly when used as fuel for operating steam plants in connection with long power-transmission lines from water-power plants. Owing to conditions which, up to the present time, are inseparable from high-tension transmission lines, steam auxiliary or standby plants in some form are a necessary adjunct to such lines where power is used to supply the various needs of a large community. Such steam plants may be required merely to supply power during brief interruptions due to transmission-line troubles, or to supply part of the power for peak loads, or to make up for deficiencies in water flow in dry seasons. For the first and second purposes mentioned they are likely to be called upon without notice and must be prepared for the emergency.

In Baltimore, the local company purchases at present about 15,000 KW. from the Pennsylvania Water & Power Co. This is transmitted over 40 miles of transmission line from the Susquehanna River, at a pressure of 70,000 volts.

The local company generates, by steam, all power for peaks over the 15,000 KW. purchased. The steam plant is operated in parallel with the water-power plant, and normally carries a constant load of about 2,000 KW., and as much over that amount as peaks may demand. In addition to this the steam plant stands prepared at all times to take the entire load should the transmission-line power fail.

So far during six months of operation there have been few interruptions on the transmission line. With but one exception these have been due to the failure of relays to operate properly. Such failures as have occurred, however, have thoroughly tested the value of fuel oil for quick steam generation. A few of these severe tests may be of interest and I will describe them.

Dec. 4, 1910.—Transmission-line service suddenly interrupted, throwing load of 10,500 KW. on five 650-HP. boilers. Oil was turned on under these boilers, which were at the time operating with coal. Steam pressure was held until transmission line service was restored. Primary voltage at substations was held within 1%.

Jan. 28, 1911.—Steam station carrying 2,000 KW. on three 650-HP. boilers, using coal, with three firemen on watch. Transmission-line service suddenly interrupted, increasing load on steam plant to 8,500 KW. Oil was turned into eight additional boilers. Steam dropped from 175 to 165 lbs., but gradually came up to 175 lbs. during the next 15 minutes. This drop in steam pressure was well within the range of automatic voltage regulators to maintain primary voltage at substation within 1%.

May 12, 1911.—Steam station carrying 2,000 KW. with four 650-HP. boilers in service, coal fired. Four additional boilers were "banked" by means of one oil burner under each. Transmission-line service suddenly interrupted, throwing load of 7,000 KW. on steam plant. Oil was turned on to four boilers in service and to four "banked" boilers. Steam pressure was maintained and in four minutes boilers were blowing off.

At the steam plant one 5,000-KW. Curtis steam turbine is kept running continuously and vacuum is maintained on several other units. The single steam turbine took the loads described in the foregoing interruptions without discomfort.

In conclusion I would say that I would be glad to give to any one who may be interested in this subject, any further details that may be desired, which, for fear of making this paper too lengthy, I may have omitted.

THE CHEAPEST GAS on record is that supplied by the City of Widnes, England, according to the "Progressive Age" of June 15. The prices have been 28.3, 24.3 and 20 cts. to ordinary customers, to those using over 3,000,000 cu. ft. per year and to those using gas for power purposes exclusively. Twenty-five cubic feet for a cent has been supplied to prepayment meter consumers. The board of directors has reduced the rates, to become effective on July 1, to the following: 26.3, 22 and 18 cts., respectively, and 27 cu. ft. for 1 ct. to prepayment meter customers. It is reported that the actual cost of gas, including interest, sinking fund and standing charges, is under 22 cts., divided into 12 cts. for manufacture and distribution and 10 cts. for standing charges. The prepayment-meter customers pay 11 cts. per 1,000 more than others, but secure their meter and fittings free. Public lighting in the past has been paid out of the profits of this municipal plant, which brings down the actual profits for the year to $22,220. The proposed reduction brings a further reduction of $8,563, which it is expected will be made up by increased consumption. The City of Widnes had a population of 39,000 in 1906. The gas works in 1909 and 1910 had 7,519 customers, 48 miles of mains and made 374,955 cu. ft. of 17.7-cp. gas. The company had a book value of $648,544, or $17.90 per mile of main, or $1.78 per 1,000 cu. ft. sold. The capital charges are 5.8% of the book value, including sinking fund. There was $447,620 interest-bearing debt and the reserve and other funds were 30.8% of the capital. The expenses per 1,000 cu. ft. of gas sold are as follows: Coal, 21 cts.; coal less residuals, 0.86-ct.; purification, .32-ct.; no manufacturing salaries; wages, 0.22 cts.; maintenance, 3.54 cts.; cost in the holder, 31.08 cts. gross, or 10.94 cts. net; taxes, 2.88 cts.; no distribution salaries, and a total distribution expense of 3.26 cts.; no expense for directors, collectors or bad debts, and 1.36 cts. for management salaries; total expenditure, 40.8 cts.; net cost after all deductions, 17 cts.; gross profit, 9.6 cts., less 5.3 cts. capital charges, gives 4.3 cts. net.

The Use of Motor Trucks on Construction Work and for Haulage Purposes.

The introduction of the motor truck for commercial service, together with its development on lines which have made a machine to be relied upon for regular service, has opened up some new fields for the use of motor vehicles. These include (1) hauling material for contracting and other construction work, both in cities and in the open country; (2) heavy haulage by manufacturers and others; (3) light commercial hauling or delivery service; (4) the operation of motor busses, mail wagons, electric railway repair wagons, police and fire department equipment, street sweepers, etc. A special class of work to which both light and heavy motor trucks are adaptable is the handling of material between the various shops and departments of large manufacturing and industrial plants. They have been applied to this class of work to some extent, taking the place of an industrial railway, and in one case careful estimates showed a material economy in favor of a motor car service as compared with a light industrial railway. Still another field, as yet but slightly developed, is the use of motor wagons in farm work.

We describe herewith a number of motor trucks and vehicles for these various classes of work, and give particulars also of their service. It is not our purpose to describe in any detail the construction of the vehicles or their mechanical equipment, but rather to indicate different varieties of vehicles and to suggest some of the fields of use to which they may be applied.

For heavy trucks the framing is generally of steel, and it must be substantially built in order to stand the severe racking stresses to which it is liable to be subjected when hauling heavy loads over rough ground. The frame is almost invariably independent of the body, so that the machine can be fitted with a body suitable for the required service. In most cases rubber tires are used, either in the form of solid flat rings or as rectangular blocks inserted into the wheel rim. In at least one case ordinary steel wheels with flat steel tires are used, while in another design the wheel rim is fitted with rows of wooden plugs 2 ins. diameter. Pneumatic tires are used on some of the lighter vehicles such as ambulances, patrol wagons, etc. Ball bearings and roller bearings are used for the wheels of some machines.

The gasoline engines are usually vertical, and placed at the front end of the frame, but some makers use horizontal engines mounted beneath the body. With the former arrangement, the driver's seat is frequently placed above the engine, to economize in length and to give a good view. In a majority of cases, the engine drives a countershaft (through the intervention of speed-changing transmission devices), and from this shaft driving chains are run to sprockets on the hubs of the rear wheels. Thus the wheels are independently driven, but in many machines there is provision for locking the wheels together or applying all the power to one wheel. This arrangement is for use in emergency, as when one chain is broken or one wheel is in a mudhole which gives it no adhesion. The almost universal practice in gasoline motor trucks is to drive the rear wheels only, but a four-wheel drive system (using bevel gear instead of chains) was described in our issue of July 12, 1906. Rear-wheel drive is used also in most storage-battery electric trucks. Independent motor-driven wheels are used, however, in other electric vehicles, current being supplied from a gasoline-electric generating plant on the heavier vehicles and from storage batteries on the lighter vehicles.

The service, fuel economy, repair expenses, etc., will depend largely upon the character of the work, the roads, and the men who handle the machines.

Motor Trucks on Contract and Other Construction Work.

While motor trucks have been used only to a limited extent as yet by contractors or on general construction work, they have been used under conditions which indicate extensive possibilities in this direction. This view is taken by some manufacturers, who are undertaking to be pioneers in the exploitation of this field, and are making strong efforts to bring the matter (and the machines) to the attention of engineers and contractors. Other manufacturers, however, consider this field to be limited and not particularly desirable. Objections made by the latter are the liability of meeting conditions which would stall a truck or put it out of service, but which could be overcome by teams by the exertion of strenuous effort. Thus heavy grades on soft wet roads, with mudholes that practically destroy adhesion, may have to be reckoned with; then, again, a truck may be given too heavy a load for the sort of road it is to haul on, but if it is made inoperative by such conditions, the blame would be laid to it rather than to the conditions or to the men in charge. In one case of which we have knowledge, a truck (on contract work) which had worked successfully on a fairly bad road during the summer, had to be replaced by teams in the early winter when deep mud combined with a frozen top crust put the truck out of service.

But even allowing for all objections, difficulties and adverse conditions, it seems evident that there are extensive possibilities for the use of motor trucks in this class of work. This is especially the case for work in the hands of modern and experienced engineering contract[illegible] who study for economy and efficiency of plan[illegible] ipment and economy of working. Such [illegible] and their intelligent subordinates, will fi[illegible]ny cases where motor trucks may develop [illegible]terial advantages. This is indicated by [illegible] of the practical experiences noted below. I[illegible]any cases material can be handled much more [illegible]dily by motor trucks than by wagons and tea[illegible]lue to the greater load, higher speed and [illegible]ter number of trips in a given time. It is [illegible]ned that the best results are under conditions [illegible]ich include full loads and good facilities for p[illegible]pt loading and unloading, but there are cases [illegible]ere speed and frequency of trips will be of mo[illegible]im portance than full loads. It has been est[illegible]ted also that under favorable conditions a [illegible]-ton dump wagon with a haul of two to four [illegible]miles can handle 120 to 150 tons per day.

The services for which motor trucks may be employed in construction work may be divided into two classes: (1) hauling material over country roads from a railway station to the site of the work; (2) hauling material over city streets. Something has been done in both these directions. The trucks used may be divided into two classes also: (1) dump carts for hauling crushed stone, sand, gravel, coal or excavated material; (2) platform and fixed body trucks for hauling cement (in barrels or sacks), quarry stone, pipe, structural steel, castings, etc. In addition to the general haulage of supplies and material, however, there are special purposes to which motor vehicles may be adapted. The hauling of large excavating machines by traction engines has been done in many cases, and in our issue of Aug. 26, 1909, we suggested that it might be both practicable and advantageous to make the lighter machines self-propelling (such as road graders and four-wheel scrapers).

The Keystone State Construction Co., of New York, has used two Mack 5-ton gasoline dump-body motor cars on its contract on the new Catskill Aqueduct for the New York water-supply. They hauled cement, gravel, machinery, etc., from Yonkers to the work, a distance of about eight miles. Two similar trucks were used for the same kind of work by the Engineering Corporation, of New York, on a contract for the Mohawk Hydro-Electric Co. The trucks ran from Gloversville to Johnstown, N. Y., about 10 miles, making about 40 miles per day with an average load of five tons. They carried cement principally, but also steel, machinery, and supplies. The detentions for repairs were few. No accurate record was kept of the fuel consumption, but the machines were stated by the manufacturers to run about 3½ miles per gallon of fuel. The machines were 18 ft. 8 ins. long over all, with a dump body 6 × 14 ft.; they had 50-HP. engines and weighed 8,500 lbs. in working

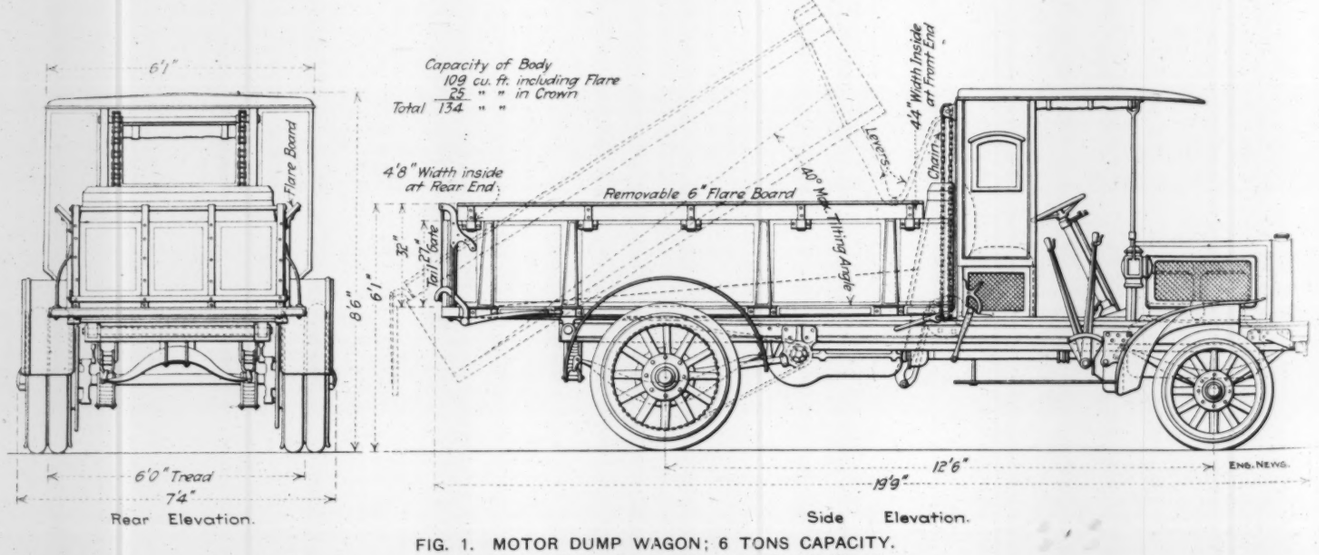


FIG. 1. MOTOR DUMP WAGON; 6 TONS CAPACITY.
(Mack Bros. Motor Car Co., Allentown Pa.; Builders.)

order (without load). A larger Mack truck, of seven tons capacity, has been used by the Goodwin Sand & Gravel Co., of New York, to deliver material for general contracting work in and about the city.

For handling steel pipe for siphons on their contract on the new Catskill Aqueduct the Snare & Triest Co. used a 7-ton Hewitt motor truck with four-cylinder 35-HP. engine. The pipe was 10½ ft. diameter, built in sections 15 ft. long, weighing 4½ to 5 tons; these sections had to be hauled about two miles from the dock at Cold Springs, N. Y., over a road having a maximum grade of 10%. The truck made 8 to 12 trips per 8-hour day, taking one pipe section each trip. The round trip averaged 40 mins., including the time for loading and unloading. The speed with load (up grade) was about 5 m. p. h., while on the return the empty truck made 10 to 15 m. p. h. The pipes were loaded upon the truck by a stiff-leg derrick, and unloaded at the work by a cableway. The fuel consumption averaged 18 gals. per day, costing about $3. The truck was fitted with wide-tired wheels, and the tires of the rear wheels were formed of rubber blocks. About 60% of the load was carried by the rear wheels.

During the construction of the new filter plant for Springfield, Mass., a truck of the Reliance Motor Truck Co. (Detroit, Mich.) was used for a part of the time to haul material from the railway. The distance was about five miles with several steep grades (maximum, 15%), the site being at an elevation of about 300 ft. above the railway. The truck had a carrying capacity of two tons, and it made usually six trips per day. It handled in all about 5,000 tons of material, including cement, iron and steel pipe, vitrified pipe, coal, castings, steel reinforcing bars, etc. The Cranford Co., of Brooklyn, N. Y., has used a 5-ton Reliance dump truck for hauling crushed stone, gravel and sand, the machine making an average of 40 miles per day.

For hauling gravel, coal, ashes, etc., the contracting firm of McDonald & Barry, of New York, has used a White motor dump truck having a steel body of three tons capacity, or about 7 cu. yds. On one piece of work, for filling low ground at Broadway and 204th St., ashes were hauled from a power-house at 224th St. and the Harlem River. The distance was about a mile and the machine made from 10 to 12 trips per day, or twice the number made by teams with loads of only 3 to 3½ yds. The machine was not operated on country roads.

Dump-Body Motor Trucks.

Motor dump wagons are applicable to various purposes for construction work and general haulage. They are particularly adapted to the hauling and distribution of broken stone, sand, gravel, coal, ashes, garbage, earth filling, excavated material, etc. A number of motor trucks with dump bodies are on the market, and some of them have been noted above. Their makers build also similar machines with fixed bodies. They include the Mack, White, Morgan, Reliance, Kelly, Hewitt, Briggs, Saurer and other makes. Most (if not all) of them are of the end dump type, operated in various ways. A drop-bottom type, as operated very largely in horse-operated wagons, appears to be impracticable with motor trucks as now built, owing to the arrangement of the machinery. However, a hopper bottom body may be used for material that will flow readily, such as coal, gravel, stone, etc. A side dump arrangement is practicable, either by tilting the body or by using a sloping bottom and movable sides. It may be noted also, that while drop bottom carts (operated by horses) are used extensively, they are open to certain objections. Among these is the blocking of the wheels by the material dumped between them.

The Mack dump truck (Mack Brothers Motor Car Co., Allentown, Pa.) has the movement of the body controlled by a link-belt chain on a drum operated by a crank handle. The chain carries a system of levers attached to the body and so arranged that as the inner end of the body is raised the lever thrusts the body backward along the frame. The machinery equipment is practically identical with that of the Mack haulage truck noted more fully further on. The dump truck is shown in Fig. 1. Some of the uses to which these dump trucks have been put have been described above. A Saurer motor-dump truck has been used by the Wayne Development Co., of Tucson, Ariz., for hauling gold ore.

The White dump truck (White Co., Cleveland, O.) has a 7-yd. body with a load capacity of three tons. The length over all is 20 ft. 7 ins., and the extreme width is 7 ft. The underframe is of steel, and for dumping the body is run back along the frame by means of a cable and power drum. The body is pivoted at the bottom at about the middle of its length, so that for dumping this pivotal point is at the rear end of the frame. The wheels are of cast steel, with solid rubber tires; the front wheels are about 40 ins. diameter and 5 ft. 3 ins. c. to c.; the rear wheels are 36 ins. diameter, with a tread of 5 ft. 5 ins. The length of wheelbase is 12 ft. The weight of the machine in working order (but without load) is 6,900 lbs. A 30-HP. gasoline engine of long-stroke is used, having four cylinders 3¾ × 5⅛ ins. The transmission is of the selective type and gives four forward speeds (with direct drive on the third speed) and one reverse speed. There is a shaft-drive from the gear case to the countershaft, which carries the differential and from which there is a chain drive to each rear wheel. The machine with full load is said to run about seven miles to one gallon of gasoline. The tanks have capacity sufficient for 125 miles run. The use of this machine has been mentioned above.

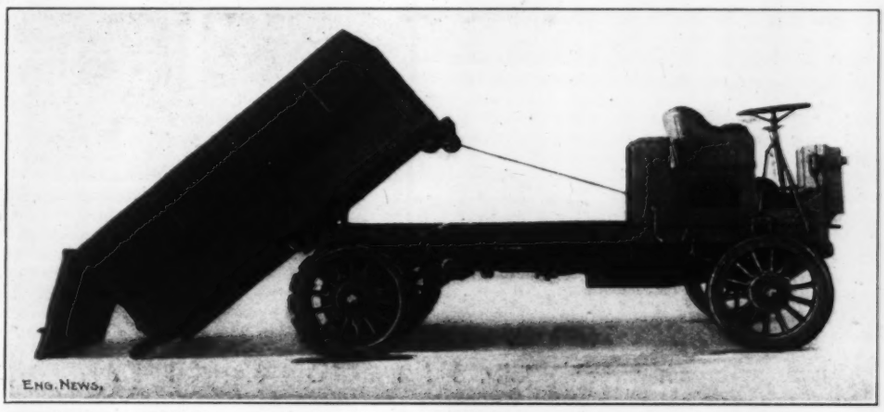


FIG. 2. MOTOR DUMP WAGON; 3 TONS CAPACITY.
(Kelly Motor Truck Co., Springfield, O.; Builders.)

The Kelly dump truck (Kelly Motor Truck Co., Springfield, O.) has a body of three tons capacity, of size as desired. The machine is about 14 ft. long, and its weight (empty) is 4,800 to 5,200 lbs. In dumping, the body is rolled backwards along the frame, its movement being effected by a cable on a worm-gear drum, operated by hand. This is shown by Fig. 2. The wheels are of the artillery type, made of hickory, and are 36 and 38 ins. diameter for the front and rear respectively. Solid rubber tires are used, although rubber block tires may be used on the rear (driving) wheels if desired. The truck with full load can ascend maximum grades of 18%. It has been used in Cincinnati for hauling coal. Its motor equipment comprises a 30-HP. gasoline engine driving a jack-shaft from which there is a double chain drive to the rear axle. The speed regulating gear is of the selective type, with sliding gear; it gives four speeds for forward motion and one for reverse. The tank holds 13 gals., or a supply sufficient for about 90 miles run. The loaded truck will run from five to nine miles on one gallon of gasoline, the consumption depending on the roads, grades, etc. The truck has not been used on rough country roads. A Kelly special dump body has been designed to be mounted on a truck of short wheelbase; the loading space is 9 ft. 4 ins. long, instead of 12 ft. 6 ins. as in the larger machine.

The Morgan dump truck (R. L. Morgan Co., of Worcester, Mass.) has been used in hauling coal. The 5-ton truck (built with dump body, fixed body, or open platform) has a 40-HP. engine, with four cylinders 5 × 5 ins., and chain drive to both rear wheels. A three-speed sliding gear planetary transmission is used, giving speeds of 6 to 10 m. p. h. The gasoline tank has a capacity of 26 gals. The frame of the machine is of steel channels, giving a platform about 14 × 6 ft.; the wheelbase is 11 ft. 9 ins. The wheels are 36 ins. diameter, with steel disks instead of spokes; solid rubber tires are used, each front wheel having one 6-in. tire, while each rear wheel has two 5-in. tires.

The Briggs motor dump wagon (Briggs Labor Saving Specialty Co., Waterloo, Ia.) is designed specially for conveying asphalt from the plant to the street, the economy over horse wagons increasing with the length of haul. It would take a heavier load and make more trips in the same time. The same type of wagon, but hauled by horses, has been built for some years, but it has not been used extensively owing to the large proportion of the load carried on the rear wheels. This feature, however, is a direct advantage in the motor truck, where the power is applied to the rear wheels. The truck is adaptable, of course, for hauling other materials besides asphalt. It is made in two sizes, with capacity of 2 yds. and 2½ yds. The weight empty is about 4,400 lbs., and the body will hold about three tons of asphalt.

The body swings between the side frames and within the end of the frames, so that it takes less space than where the body is moved backward to the dumping position. When at its lowest position it is clear of the ground. The end gate swings upward and outward as the body tilts downward. The movement is under close control, so that the machine can be used to spread or distribute the material as required. The body is returned to normal position by a cable and hand-operated drum.

An Anderson horizontal engine, with two opposed cylinders 5½ × 5 ins., is mounted beneath the forward part of the frame and carries a heavy fly-wheel. The transmission is of the planetary type, with no shifting gears, and gives two forward speeds and one reverse speed. With the high-speed clutch engaged (for 8 m. p. h.), no gears are in action, all the gears being locked so that the entire transmission revolves as a unit. There is chain drive from a sprocket on the transmission to one on the differential or countershaft, from which there is chain drive to each rear wheel. A special feature of the machine is that it has no rubber tires, being equipped with wide-tired all-steel wagon wheels.

Motor Trucks for Heavy Haulage.

Motor trucks of 3 to 10 tons capacity are used for various classes of work, such as hauling coal, lumber, structural steel, heavy machinery, safes, gravel, quarry stone, cotton bales, cement, etc. In most cases they work on city streets, but sometimes also on country roads. Some of the

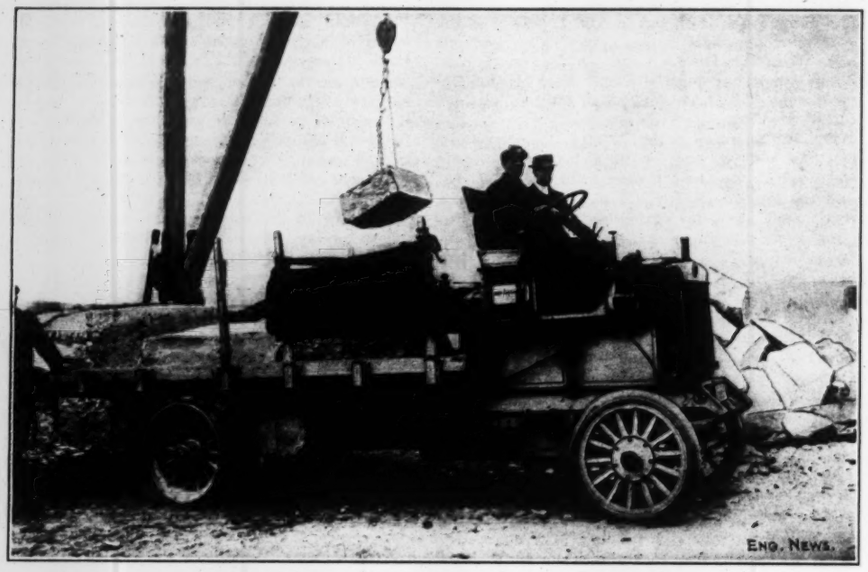


FIG. 3. MOTOR TRUCK IN QUARRY SERVICE; 4 TONS CAPACITY.
(Alden Sampson Mfg. Co., Detroit, Mich.; Builders.)

machines are fitted with a power hoist for handling heavy or bulky goods (and raising or lowering safes), or with a jib crane for loading and unloading such goods.

The following particulars give an indication of the possibilities of machines of this class. In New York, a Sampson truck with a 4-ton load was run 65 miles through crowded streets and over steep grades in the suburbs; its average speed was 11 m. p. h. and its operating cost 0.88 cts. per ton-mile ($4.98 for 524 ton-miles). Near Chicago, a similar car made an average of 8 m. p. h. on bad roads. A Kelly truck made the 120-mile run from Philadelphia to Atlantic City and return at a cost of 0.7 cts. per ton mile. A Mack 3-ton truck at Allentown, Pa., has worked regularly over hilly country in spite of general rough conditions of roads, soft roads in spring, snow in winter, and grades as high as 15%. A Kelly 3-ton truck hauled a total of 1,000 tons on country roads, delivering at various places within 12 miles of a factory, at an average of six miles per gal. of gasoline and a speed of 8 to 12 m. p. h. This machine displaced eight horses and three wagons, and the horse-operated service did not extend more than six miles from town. At Cleveland, O., a tool company used a Kelly 3-ton truck for hauling freight to and from freight stations 3½ to 8 miles distant; it took the place of one two-horse wagon and one one-horse wagon. The motor truck could make four such trips daily (as against two for the two-horse wagon) besides making light deliveries about the city.

As to long distance work, in 1910 a truck of the Grabowsky Power Wagon Co., of Detroit (with its full 2,000-lb. load), made a run from Detroit to New York at an average speed of 14 m. p. h. A still greater test was made with a motor truck of the Saurer Motor Co., New York, which started in March, 1911, to run from Denver to San Francisco and thence to New York.* The machine weighed about six tons, including a 3-ton load of lumber (to bridge creeks) and camp equipment. In spite of deep mud, snow, sand, absence of roads, weak bridges, and the occasional necessity of fording streams, the machine continued to make headway, although sometimes at very slow speed, such as 38 miles in 9½ hours. Its ability to overcome such obstacles and adverse conditions indicates the strength and reliability of motor trucks.

The Sampson motor truck (Alden Sampson Mfg. Co., Detroit, Mich.) is made in sizes having load capacities of ¼-ton to 5 tons, and the body in each case is of a shape suitable to the character of the load. The engine is mounted at the front end just behind the front axle; it has four cylinders, 4×5 ins. for the 1-ton to 5×5½ ins. for the 4 and 5-ton machines, the latter being rated at 40 HP. The transmission is of the selective sliding-gear type, giving speeds of 1 to 10 m. p. h. In the differential gear a special feature is an interlock which enables all the power of the engine to be applied to one wheel. This is for use in emergency, as when one driving chain is broken or one wheel is in a soft spot which affords no adhesion. There is a driving chain to each rear wheel, the chains being outside the frames and enclosed in protective steel casing. The frames are of pressed steel. The wheels are of the artillery type, with solid rubber tires on the front wheels and rubber-block tires on the rear wheels. On the 5-ton truck the wheels are 36 ins. diameter, with a single tire 6 ins. wide on each front wheel and two 5-in. tires on each rear wheel. The tank capacity of the larger machines is 30 gals. The 5-ton truck has a wheelbase of about 13 ft., with a width of tread of 5 ft. 6 ins. for the front and 6 ft. 8 ins. for the rear wheels. The size of platform (available for body) is 14 ft. 6 ins. This truck weighs about 4 tons complete, and is said to run about four miles to one gallon of gasoline.

A 5-ton Sampson truck equipped with a motor hoist is used in New York for transporting safes, and raising or lowering them at the buildings. A 4-ton truck with open platform for large quarry stone is used by the Quincy Quarries Co., at Quincy, Mass. This is shown in Fig. 3. In a ten-hour day test, the truck made 12 deliveries from the quarries to various companies in Quincy. The total weight of the day's haulage was 53 tons. The smallest load was 7,900 lbs., the largest 11,000 lbs.; the truck negotiated [illegible] miles. Only 17 gals. of gasoline and 1 [illegible] lubricating oil were consumed. The total cost of these was $2.17. The driver's salary was $3. The allowance for depreciation and interest was approximately $8.70. This made the total expense for the work $13.87. By loading and unloading 24 times the average speed for the day was 6 m. p. h. The actual average during the test, however, was 11 m. p. h. This work, when done by horses required the services of three teams. A Sampson 4-ton truck with deep body (Fig. 4) is used by H. L. Herbert & Co., of New York, for carrying coal; the truck will haul a trail wagon, making a total of 9 tons of coal. A six-day test was made with this truck, averaging five loads per day, and the general results are given in Table I.

TABLE I.—PERFORMANCE OF MOTOR TRUCK IN HAULING COAL.

Day.	Running time, mins.	Wt. of load, lbs.	Total miles.	Gasoline, gals.	Oil, gals.	Ton-miles.
1.....	125	45,300	12.1	10	1	274
2.....	276	84,700	27.8	15	1½	1177
3.....	255	109,400	21.0	15	1	1147
4.....	225	87,500	18.7	15	1½	827
5.....	350	114,300	27.0	15	2	1543
6.....	195	93,400	20.0	14	1½	934

Some exceptionally large motor trucks, of 10 tons capacity, are used by the Burns Brothers Co. in hauling coal from its yards in Jersey City to various consumers within a 20-mile radius in New York, Yonkers, Coney Island, Flushing, etc. In this service they operate on country roads as well as in city streets. These cars are of the Hewitt type (Metzger Motor Car Co., New York, N. Y.). The coal company's business calls for the supply of coal in large quantities. Experiment with one of these trucks indicated that it would afford the most satisfactory means of transportation and ten more were ordered. The truck is 15 ft. long and 7½ ft. wide over all, weighing about 6 tons empty. It has a 40-HP. engine, with planetary transmission gear giving two speeds forward and one reverse speed. The speed of the engine is regulated by a governor, and there is the usual chain drive to each rear wheel. The gasoline tank has sufficient capacity for a run of 100 miles. The front and rear wheels are 36 ins. and 44 ins. diameter, respectively; all with double-width tires composed of rubber blocks. The lower part of the body flares out over the wheels so as to give the vertical sides of the upper part the full width over the wheels. The discharge is by a gate in the lower part of each side. A record of the performance and operating cost of one of these 10-ton trucks was given in our issue of Jan. 13, 1910.

The Mack motor-truck with fixed body (instead of the dump body described above) is 18½ × 7 ft. over all, with body 14 × 6 ft. The wheels are of wood construction, 36 ins. diameter for

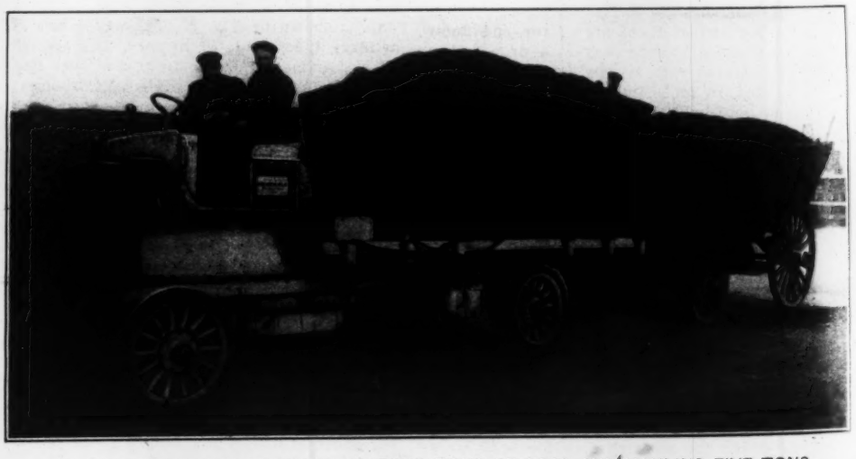


FIG. 4. A MOTOR TRUCK CARRYING FOUR TONS OF COAL AND HAULING FIVE TONS IN A TRAIL WAGON.

*Engineering News, April 20, 1911 (p. 493).

the front and 42 ins. for the rear wheels, with solid rubber tires. The 5-ton machine weighs 8,500 lbs., and the 7-ton machine 10,000 lbs. in working order, with tanks filled. A 50-HP. engine is used, and the average fuel consumption is 1 gallon for 3½ miles, with full load. A run of 100 miles can be made without refilling the tanks. The trucks are operated on country roads as well as on streets, and are said to be capable of taking the full load up grades of 20%. The 7-ton truck has a four-cylinder water-cooled engine (5½ × 6 ins.), running at 900 r. p. m., and developing at this speed 60 HP., according to the American rating system, or 48 HP., according to the French rating system. The gasoline tank has a capacity of 28 gals., which will provide for a working radius of 100 miles under normal conditions. With a full load on a level road the engine will run three

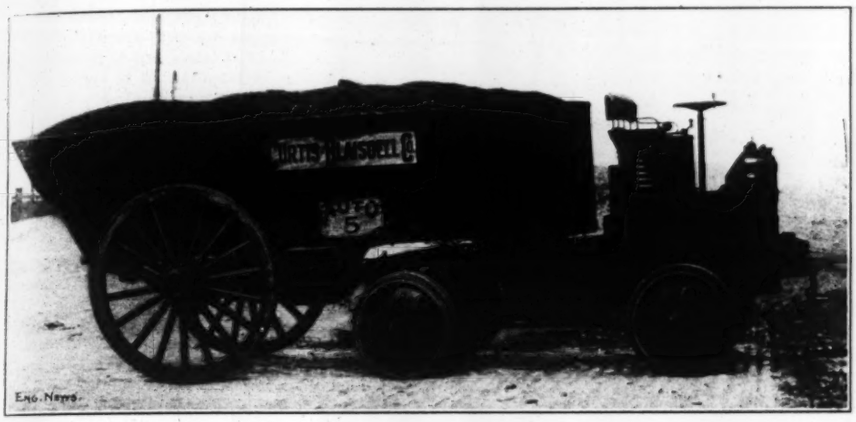


FIG. 5. AN ELECTRIC MOTOR TRUCK WITH 10-TON LOAD OF COAL.

(The Couple-Gear Freight-Wheel Co., Grand Rapids, Mich.; Builders. This machine has motor drive to all the four wheels of the tractor.)

miles on one gallon of gasoline. Such a machine will handle from 100 to 140 tons per 10-hour day with a haul of two miles; this allows 3 mins. for loading and the same for unloading. Several of these 7-ton trucks, with deep bodies, are used by Charles Loveland, of Wilkes-Barre, Pa., for handling coal. They have worked in snow that made the roads almost impassable for teams.

The following comparative estimate of daily cost for a 5-ton motor truck and a good team is submitted by the Mack Co. (Table II.):

TABLE II.—COMPARATIVE PERFORMANCE AND COST OF TEAM AND MOTOR TRUCK.

	Good team outfit.	5-ton Motor truck.
First cost	$1,000	$5,000
Time in service	6 hours	7 hours
Service	3 tons, 20 miles	5 tons, 60 miles
Ton-miles	60	300
Cost per day	$6.50	$13.00
Cost per ton-mile	0.11	0.04½
Investment per ton-mile	17.34	17.00

Operating cost for truck (60 m. per day):	
Gasoline, 3½ cts. per mile	$2.10
Oil, 1 ct. per mile	.60
Repairs and renewals, excl. of tires	1.50
Tire maintenance	3.00
Interest and insurance, 6%	1.25
Depreciation, 10%	1.50
Operation	3.34
	$13.29

Two more cases of the use of motor trucks in handling coal may be mentioned. For hauling its supply from the railway coal chutes at Syracuse, N. Y., to the power plant of the Syracuse University, the university has a 5-ton motor truck. This is not a dump truck, but is loaded by gravity at the chutes and delivers its load by gravity through a chute to the underground bins. The haul is 3½ miles, with grades of 7 to 12% against the load. The truck hauls 45 tons per day as an average. The Milwaukee-Western Fuel Co. uses a bottom discharge coal wagon for supplying coal to the Wells St. power station of the Milwaukee Electric Ry. & Light Co. The wagon stands over a hopper feeding underground bins.

The Texas Co. uses Mack motor tank wagons for hauling oil, etc. The tank is 46 ins. diameter and 12 ft. long, divided into three compartments of 410, 370 and 220 gals. capacity. The Standard Oil Co. uses Saurer motor tank cars for hauling fuel oil. The tank has a capacity of 31 bbls.

The handling of structural steel by teams is likely to offer many difficulties, and a steam motor truck of special design, built by the Geo. W. Jackson Co., of Chicago, for its own use was described in our issue of April 7, 1910. The Kansas City Structural Steel Co. uses a 3-ton Kelly truck to run between its plant and the city, a distance of 6⅛ miles. Three round trips are made daily, as against one with a horse team. Although the city is very hilly the truck can go to all parts. The Scully Steel & Iron Co., of Chicago, uses a Garford truck (Garford Co., Elyria, O.) for carrying structural steel and general iron work. The Crane Co., of Chicago, uses a 3-ton Alco truck (American Locomotive Co., New York, N. Y.) for carrying iron pipe and supplies. In 52 days' service, this truck carried about 288 tons and traveled 1,675 miles, with a consumption of 379 gals. of gasoline; its daily load was from 3,650 to 25,650 lbs., and its daily run from 17 to 44 miles.

Electric and Gasoline-Electric Motor Trucks.

Storage-battery electric trucks and delivery wagons of 300 lbs. to 3 tons capacity are made by several makers. Several hundred such trucks are in use by department stores, manufacturers and express companies, chiefly for delivery work in large cities. For the trucks of the Lansden Co. (Newark, N. J.), equipped with the new Edison battery, the distance run with one charge is claimed to be 75 miles for the lightest vehicles to 30 miles for those of 3 tons capacity.

Storage-battery electric trucks for both light and heavy service, and with load capacity as high as 10 tons, are built by the Studebaker Bros. Mfg. Co. (Chicago). Several 8-ton electric trucks of this kind are used by the American Sugar Refining Co. of New York, and the U. S. Naval Gun Factory has trucks of 3½ and 5 tons capacity for service around the plant and in the city. The Piercy Contracting Co. uses trucks of 1,000, 2,000 and 7,000 lbs. carrying capacity in its teaming and delivery business. The batteries have 25 cells. The motors are designed to operate on specific discharge of the battery at a fixed voltage, the overload capacity varying with the make of the motor; the motors on the largest trucks are rated at 35 amperes 80 volts. The 8 and 10-ton trucks weigh about 11,100 lbs. in working order (including batteries); they can attain a speed, when loaded, of 6 m. p. h., and can run 28 miles without recharging the batteries. These machines have chain drive to the rear wheels.

A gasoline-electric motor truck of 10 to 12 tons load capacity has been designed by the Great Western Transportation Co. (Chicago) for heavy hauling of freight, ore, etc., in western mining and agricultural districts. A cab at the front end contains the machinery, which includes a six-cylinder engine (5½ × 6 ins.) directly connected to a 20-KW. generator. Current is supplied to two 15-HP. motors, each operating a chain drive to one of the rear wheels. The wheels are 4 ft. diameter, of the artillery type, running on ball bearings and having steel tires 12 ins. wide. The speed with load is about 6 m. p. h., and the tanks carry sufficient fuel for a run of 150 miles. The weight of the truck in working order (with tanks full) is about 7 tons. Two of the tracks are now in operation at Kingman, Ariz.; they haul ore and general freight and have a run of 18 miles.

In two styles of electric motor trucks, however, every wheel is driven directly by gears which mesh with an internal circular rack inside the rim of the wheel. The mechanism is enclosed between two dished steel disks which are used instead of spokes. In the large machines of the Couple-Gear Freight-Wheel Co. (Grand Rapids, Mich.) current for the wheel motors is supplied by a gasoline engine and electric generator on the car. Within the wheel is a motor, having a pinion at each end of its shaft; each pinion gears with a spur wheel which in turn gears with an internal circular rack on the rim of the wheel, there being two separate racks. The two intermediate gear wheels are on opposite sides of the axle, so that they both drive in the same direction. All the wheels are operated simultaneously in steering. The first machine was used in 1906 for transporting the great telescope to the observatory

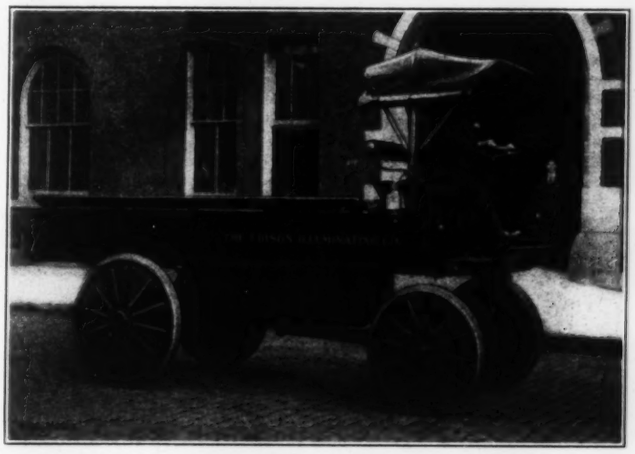


FIG. 6. A LIGHT ELECTRIC MOTOR TRUCK, WITH MOTOR DRIVE TO ALL WHEELS.

(Automobile Maintenance & Mfg. Co., Chicago; Builders.)

on Mt. Wilson in California. Another was built for the U. S. War Department for experimental field service, and the third was an emergency or tower wagon for the Chicago City Ry. The Curtis-Blaisdell Co., of New York, is using three of the 5-ton machines, while the Stephens Bros. Coal Co. and the Leonard Bros. Coal Co., of New York, have each a 3½-ton truck; a 3½-ton truck is used also by the Cincinnati Ice Co.

The machine is 18 × 7 ft. over all, with 12 ft. of body loading space, and a weight of 5 tons empty. It is mounted on 36-in. wheels, each having two solid rubber tires 5 ins. wide. The wheelbase is 12 ft., and width of tread 5½ ft. The 50-HP. engine has four cylinders 5¼ × 6 ins. The generator is rated at 12½ KW. at 110 volts, 680 r. p. m. The speed is from 1 to 8 m. p. h., and runs of 25 to 50 miles can be made without refilling the tanks (16 gals.). On good roads the machine will run 2½ miles per gal.

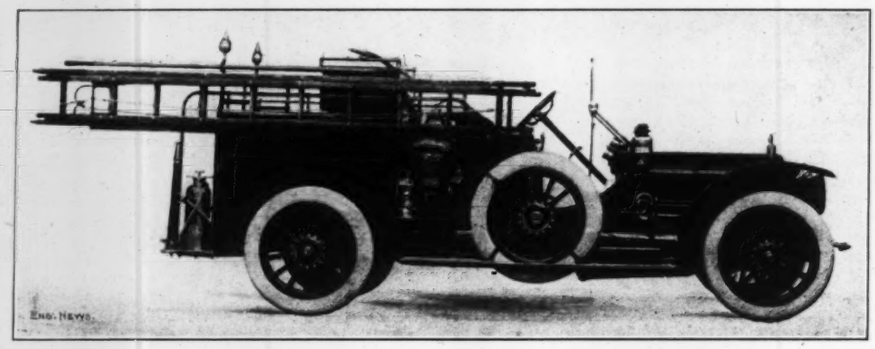


FIG. 7. A MOTOR CHEMICAL AND HOSE TRUCK FOR FIRE DEPARTMENTS.
(Thomas B. Jeffery Co.; Kenosha, Wis.; Builders.)

of gasoline. A dump body may be fitted, operated by a system of levers. An interesting feature is that the machine may be built for use as a tractor to which a box wagon (for coal) or a platform wagon (for lumber or structural steel) may be attached. With this arrangement, making a six-wheel machine, as shown in Fig. 5, the load may be increased to 10 tons. With this load the machine can ascend grades of 10%.

The Walker storage-battery electric trucks (Automobile Maintenance & Mfg. Co., Chicago) are lighter machines with a somewhat similar driving mechanism, but the motors are not inside the wheels. A motor is mounted on each axle, and its shaft projects through the wheel hub, carrying a pinion inside the wheel. A horizontal arm carries two spur wheels which mesh with the pinion and with a circular rack inside the rim of the wheel. To the rim is fitted a solid steel tire. The wheel center is composed of a pair of dished steel disks which enclose the mechanism. The trucks are built with a carrying capacity of 700 to 3,000 lbs., and have wheels of 34 to 42 ins. diameter. Some electric companies use these trucks for tool, repair and emergency wagons, and for handling supplies. The Commonwealth Electric Co., of Chicago, has a number of these machines, and the records of six trucks of 3,000 lbs. capacity, for a period of 19 months, are shown in Table III. A similar wagon used by the Edison Illuminating Co., Detroit, Mich., is shown in Fig. 6.

TABLE III.—PERFORMANCE OF WALKER ELECTRIC MOTOR TRUCKS (3,000 LBS. CAPACITY).

Total miles traveled		63,235
Average per wagon per month		723
Ave. miles per day in service		30.6
Ave. days in service per month		23.7
Ave. KW.-hrs. per mile		0.426
	Per month, dollars.	Per mile, cts.
Ave. cost: Supplies and repairs.		
Oil and supplies	$3.13	0.4
General repairs	14.07	1.9
Energy (4 cts. per KW.-hr.)	12.24	1.7
Total	$129.44	4.0
Purchase and repair of tires	7.16	1.0
Purchase and repair of batteries	1.91	0.3
Fixed charges and general expenses:		
Driver's wages	65.00	9.0
Supervision	5.22	.7
Rent of garage	5.18	.7
Wheel tax	2.67	.4
Washing, oiling, etc.	13.00	1.8
Interest 5%, taxes 1.5%, and insurance 0.5% on total cost.	14.58	2.0
Depreciation, per year:		
Batteries, 6.6% on $225	14.17	2.0
Tires, 100% on $225	18.80	2.6
Balance of wagon, 10%	15.99	2.2
Total gen. exp. and fix. charges.	$154.61	21.4
Total supplies and repairs	29.44	4.0
Grand total expense	$184.05	25.4

Municipal Service.

The use of motor vehicles in municipal service may include machines of three classes: (1) those of light weight, such as police and fire patrol wagons, ambulances, etc.; (2) those of heavier weight, such as fire engines, ladder trucks and other fire department apparatus; (3) street sweepers and sprinklers, garbage wagons, electric light repair wagons for streets and parks, and other miscellaneous equipment. Machines of the first two classes are in extensive use and are made by several manufacturers. An example is shown in Fig. 7, representing a Rambler combination chemical and hose truck (Thomas B. Jeffrey Co., Kenosha, Wis.). This has 36-in. and 37-in. wheels with 5-in. pneumatic tires; wheelbase, 11 ft. 8 ins.; width of tread, 4 ft. ins. It has tanks for 13 gals. of gasoline 7 gals. of water. A four-cylinder engine HP. is used, and the range of speed is fr to 40 m. p. h. The weight in service, in all equipment, is about 5,500 lbs. The ma has no pumps, but carries a 40-gal. che tank, two 3-gal. hand extinguishers, two ex sion ladders, 200 ft. of hose in 50-ft. len and a supply of tools, pike poles, etc. The can carry 850 to 1,000 ft. of hose, and the accommodation for six men. In a period of months a Rambler motor fire truck at K sha, Wis., answered 39 alarms and made a as many more inspection runs. The total for gasoline, oil and water was $1.37 per mo while formerly it cost $1.25 per day for feed shoeing, bedding and doctoring the pair of ho for the fire truck.

A Knox motor fire-engine (Knox Automo Co., Springfield, Mass.) has a six-cylinder eng of 60 HP. for propulsion and for the pump The machine is 22 ft. long and 6 ft. wide, with a wheelbase of 14 ft. 2 ins.; it is carried on 10-in. wheels with solid rubber tires. The tanks have capacity for 35 gals. of gasoline and 11 gals. of cooling water, but while the engine is driving the pumps the cooling water is taken directly from the discharge side of the pump and the radiator is not used. The machine weighs about 10,000 lbs. in service order, and can attain a speed of 30 m. p. h.

The pumps are of the double reciprocating plunger type, driven from the main shaft by means of a Henley spiral worm gear and a double Renold silent chain. This arrangement furnishes one gear ratio for ordinary conditions and another for extraordinary conditions. The nominal rated pump capacity is 600 gals. per min., with suction from 8 to 10 ft. and 120 lbs. pressure at the pumps. The equipment includes a 35-gal. chemical tank and 200 ft. of chemical hose, extension and roof ladders, firemen's tools and appliances, and two 10-ft. lengths of non-collapsible suction hose. The body will accommodate 10 men (besides two on the front seat) and 1,000 ft. of 2½-in. hose, while about 12 men can be carried on the running boards if necessary. Machines of this sort have been built for New York City, Richmond (Va.) and Haverhill (Mass.). In this case, the one engine serves for propulsion and for operating the pumps, but motor fire-engines are made also in which the ordinary boiler and steam pumps are used, the gasoline engine operating only the propelling mechanism.

Among the larger class of fire apparatus may be noted a 65-ft. water tower with six-wheeled truck for New York. The truck proper (carrying the tower) has only the two rear wheels, its front end being pivoted upon a four-wheel electric tractor of the Couple-Gear system, as shown in Fig. 5. This machine weighs 7 tons, and can be run at any speed up to a maximum of 15 m. p. h.

Two motor street sweepers may be noted. The Briggs Labor Saving Specialty Co. (Waterloo, Ia.) builds a steel-frame steel-wheel machine with a revolving broom delivering the dirt onto a conveyor which discharges it into a chamber;

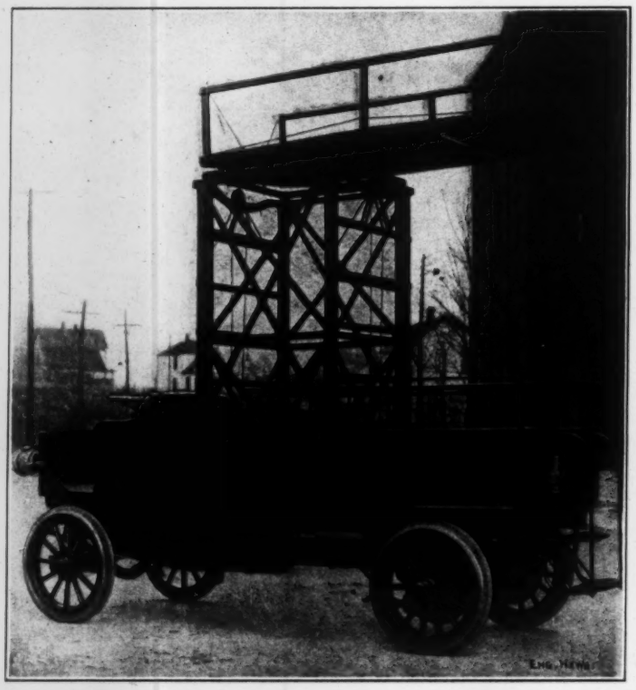


FIG. 8. A MOTOR TOWER WAGON FOR ELECTRIC RAILWAY SERVICE.
(Kelly Motor Truck Co., Springfield, O.; Builders.)

FIG. 9. COMBINED MOTOR TRUCK AND TRACTOR FOR FARM AND COUNTRY WORK (HAULING A ROAD GRADER).
(The Avery Co., Peoria, Ill.; Makers.)

this can be dumped at intervals. A two-cylinder horizontal engine running at 750 r. p. m. carries two sprockets on its main shaft; one of these drives the differential jack-shaft, from which driving chains lead to sprockets on the 36-in. rear wheels; the other drives the shaft from which chain drives operate the broom and the conveyor. The high speed (with no gears in action in the transmission) is 4¼ m. p. h. The broom runs at constant speed, independent of the speed of travel of the machine; this is an important advantage over horse sweepers in which the broom is driven from the carrying wheels. A larger and heavier machine, built by the Emerson Contracting Co., of New York, is intended to haul the dirt to the dump. The broom delivers the dirt to a conveyor which discharges it into a large storage bin. The machine is mounted on four wheels of the automobile type, and a 40-HP. engine supplies power for propulsion and for driving the broom and conveyor. Both of these machines are experimental, and of course they are not the only ones of the kind. A 7-ton Mack motor dump wagon has been used by Joseph Murphy & Son, of New York, for plowing snow from the streets and then hauling it away. It is estimated that in 18 hours' work (two 9-hour shifts) it did the work of 200 men.

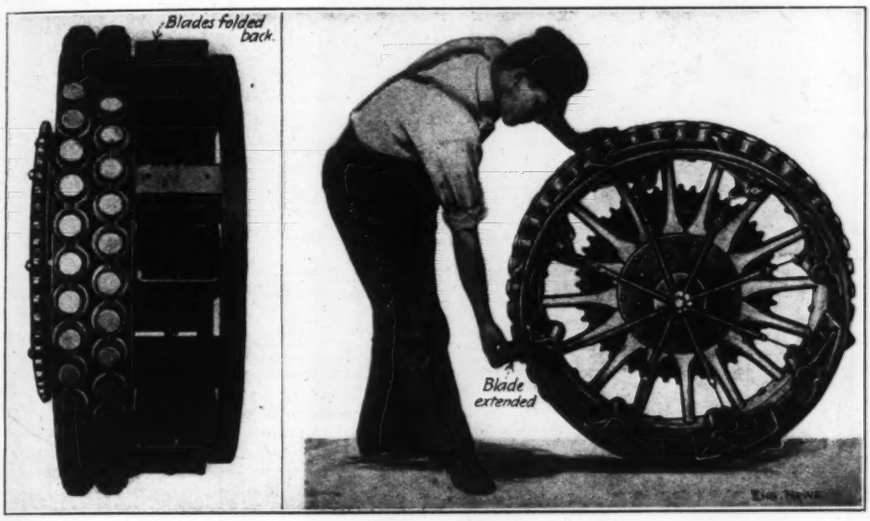


FIG. 10. DRIVING WHEEL OF THE AVERY MOTOR TRUCK.
(The 2-in. wood plugs form the bearing surface; the hinged blades in the extension tire may be made to project and give positive grip in soft ground).

Miscellaneous.

Motor trucks and vehicles may be adapted to a variety of miscellaneous uses, of which a few are noted below.

LIGHT HAULAGE.—This is practically identical with the local delivery service operated by numerous firms in many large cities, and there are many classes of manufacturing and supply firms to whose business a similar service might be adapted to advantage. Delivery wagons of 1,500 to 2,000 lbs. capacity, built by the Chicago Commercial Car Co., operating in various mercantile lines in Chicago, are said to have an average operating cost of 2 to 2½ cts. per mile run (including maintenance and depreciation). In several cases one motor truck does the work which formerly required three horse-drawn wagons.

MAIL WAGONS.—The U. S. Post Office Department uses motor mail wagons in several cities. The 25-HP. Overland wagons (Willys Overland Co., Toledo, O.) are used in Indianapolis, and it is said that each does the work of three horse-drawn wagons. They have averaged 60 to 75 miles per day for over two years, and have been able to run even in heavy snow.

TOWER WAGONS.—Several street railway companies are using motor tower wagons for repairs to overhead equipment and for general emergency work. They can travel faster and can be handled better than horse-drawn wagons. The Kelly wagon (Kelly Motor Truck Co., Springfield, O.), shown in Fig. 8, is very similar to the dump truck already described except as to the form of the body. The body is 17 ft. long and the machine has a carrying capacity of about two tons. These machines are used by the Metropolitan Street Ry., Kansas City; the Oakland (Cal.) Traction Co., the Los Angeles Electric Ry. and the Omaha & Council Bluffs Ry. At Omaha the machine has run about 2,800 miles with an average of ⅓-gal. of gasoline per mile. The machine has a 30-HP. four-cylinder engine and can be run at 18 m. p. h. An electric tower wagon has been mentioned already. Similar machines are used for electric lamp repair work.

MOTOR BUSSES.—These include vehicles for stage lines, hotel service, sight-seeing trips, etc. A machine with a front vestibuled entrance for the prepayment system is built by the Mack Co., and various designs are built by other makers. The Wilkes-Barre (Pa.) Motor Transit Co. has operated a service of this kind for about three years, using four Mack machines which seat about 24 passengers each. One of these ran about 15,000 miles in six months, being on the road from 7 a. m. to 6 p. m., and during that time it was hardly off the road for more than an hour at a time for repairs. A similar vehicle was used to carry passengers between Schroon Lake, N. Y. and the nearest railway station, a distance of 17 miles.

FARM SERVICE.—The use of steam traction engines for hauling and operating heavy farm machinery has been followed by the introduction of gasoline tractors for the same service. A more recent development, however, is the introduction of motor wagons for work both on the farm and on the country roads, thus reducing the number of horses required and the troubles incident to their use and keep. These machines are not intended to replace the large tractors for heavy plowing and other work (such as is required on very large farms); but they can do ordinary plowing, and can travel over plowed ground (pulling harrows, seeders, etc.) without packing the soil. They may be used also to haul supplies to the larger machines, and to haul grain, etc., from farm to town or railway. In addition to the hauling, the motor wagon can drive stationary machinery (pumps, hay balers, feed grinders, etc.), or operate hoisting tackle for building and other work as well as helping to load and unload heavy freight. In Fig. 9 is shown one of the farm motor wagons, built by the Avery Co. (Peoria, Ill.), and in this case the wagon is hauling a road scraper. It is shown with stake sides for the platform, but a hay rack, cattle rack, box body for grain, etc., can be mounted as desired. A four-cylinder engine of 45-HP. (brake) is used, and the weight of the wagon complete is about 5,875 lbs. This type of motor wagon would be adaptable also to the haulage for contracting or construction work, such as is described in the earlier part of this article.

One of the special features of this wagon is the type of wheel employed, and this is shown in detail in Fig. 10. The rim is of cast steel, and has two rows of pockets to receive hard wood plugs 2 ins. diameter. This construction is much cheaper than the use of rubber tires and the wheels operate satisfactorily over fields and country roads. They can run also on paved streets, but are not so well adapted for this service, and when the wagon is to run regularly on such streets it may be fitted with hard rubber tires. The driving wheels have extension tires, and when hauling on soft ground, eight blades can be made to project about 4 ins. from each extension, thus getting a good grip or bite in the ground. The blades may be thrown entirely out of action, or (when running on a road) they may be locked in such position as to be slightly within the circle of the tread of the main wheel, but to come into play if the wheel should strike a soft spot. All the wheels run on roller-bearings.

FREIGHT HAULING ON COUNTRY ROADS.—Very little has been done as yet to develop this field of operations, but that it is a practicable field is indicated by the use of large motor trucks by some large dry-goods, grocery and other firms for distributing packages not only to suburban districts but to distances of 20 to 30 miles from the cities. The Abbott & Miller Auto Express Co., of Quincy, Mass., uses four Kelly 3-ton trucks for its service between Quincy, Milton and Boston. It is stated that each truck does in one hour what would take a two-horse team 2½ hours.

A trip from New York to Philadelphia and return with a heavy load is an example of such work. This was made in April by a Commer gasoline truck (Wyckoff, Church & Partridge, New York) carrying 4½ tons on the outward run and 3 tons on the return run; six men were carried also. The outward run was made in 7 hrs. 35 mins. (including 35 mins. delay at the ferries); the return was made in 7 hours. The distance was 220 miles, covered at an average speed of 15¾ m. p. h., and at an approximate cost of 19.8 cts. per mile.

The total cost was $42.26. The cost and time of the trip were less than by express, and the latter method would have necessitated carting the freight (including a piano and furniture) to the station, loading it into a car, unloading it and carting it to its destination. The cost has been given as in Table IV.:

TABLE IV.—COST OF OPERATION OF A MOTOR TRUCK FOR 220 MILES RUN ON COUNTRY ROADS.

Driver ($20 per week) day's work plus 5 hours at 50% overtime	$6.16
Gasoline, 40 gals. at 11 cts.	4.40
Lubricating oil	.20
Grease	.20
Maintenance, 4 cts. per mile	8.80
Tires, 7 cts. per mile	15.40
Insurance, 50 cts. per day ($150 per year)	.50
Depreciation, 3 cts. per mile	6.60
	$42.26

A special motor road-train for service of this kind has been devised and built by the Alden Sampson Mfg. Co. (Detroit, Mich.), but as yet it has been used only for experimental and exhibition work. It consists of a six-wheel gasoline tractor and six-wheel trail wagons. The train is considered to be adaptable for commercial and military purposes.

In all such work outside of cities the character of the roads and bridges is an important factor, but the possibilities of such service are indicated by the notes already given of the performance of some trucks in regular service and of the runs by commercial motor trucks, from Denver to San Francisco and New York, and from Detroit to New York.

Tables for Use in Determining Earth Pressure on Retaining Walls.

By W. E. WESTON.*

The accompanying table, which was prepared by the writer a number of years ago, has proved so satisfactory in solving the theoretical formulas for earth pressures upon either vertical or inclined walls, that he has placed it before other engineers in the hope that it may prove a labor-saver to them also.

The method employed has been to find the increase of pressure per vertical foot, from which the pressure at any desired depth may easily be obtained.

This method is especially adapted to finding the pressure on horizontal beams framed at different depths below the surface. For example, knowing the pressure per vertical foot, let it be required to find the pressure on a beam framed at a depth h from the surface, when the beams are spaced a distance apart equal to a. (See Fig. 1.) Then the pressure on the beam for one foot in length will be the pressure per vertical foot multiplied by ha.

While the method is the same in all cases, a number of examples will be given to illustrate the different conditions which would ordinarily be met with in practice. By the aid of graphics to get resultants, in connection with the given coefficients, all the problems may easily be solved.

Referring to Fig. 2, let:—

P = Total pressure on AB for 1 ft. of length.
ϕ = Angle of repose of material.
w = Weight of 1 cu. ft. of material.
C = Coefficient for angle ϕ.

It is required to find the total pressure on a vertical plane AB, the surface of the ground AC being horizontal.

Then we have $P = \frac{wh^2}{2} C$

P will be horizontal and applied at 1/3 h.

In the case of a uniform surcharge let:—

g = Pressure of surcharge per sq. ft. of surface.

Then ghc = total pressure on AB due to surcharge.

As the pressure is the same for each foot of height, the point of application will be at ½ h.

If it be required to find the pressure on a portion of a vertical wall as BD (Fig. 3), when the surface of the ground AC is horizontal we have:—

wC = Horizontal increase of pressure per vertical foot.

For example:—

Let angle of repose $\phi = 32°$.
" weight per cu. ft. of material $w = 80$ lbs.
" $h = 10$ ft. 0 ins.
" $BD = 4$ ft. 0 ins.

By using the table of coefficients we find the increase of pressure per vertical foot $= 80 \times 0.3073 = 24.58$.

Therefore the horizontal pressure
at $D = 24.58 \times 6 = 147.48$ and
" $B = 24.58 \times 10 = 245.8$ and

$$\frac{245.8 + 147.48}{2} = 196.64 = \text{the}$$

average pressure per vertical foot on BD.

$196.64 \times 4 = 786.5 =$ Total pressure on BD for one foot of length.

To find the point of application of the resultant draw the trapezoid $abcd$ (Fig. 4) to represent the pressure diagram. Then the center of gravity of the trapezoid will give the distance above the base of the point of application of the resultant pressure on BD. In this example the distance is 1.83 ft.

The Plane AB Inclined.

For the pressure on an inclined plane we will refer to Fig. 5. It is required to find the pressure on the plane AB when AC the surface of the ground is horizontal.

We first find the horizontal force p_2 and the vertical force p_1, and the resultant of these two forces will give the amount and direction of the required pressure on AB.

The vertical force p_1 will be the weight of the material directly above the plane AB, viz., the triangle ABF. The horizontal force p_2 is the same as it would be on a vertical plane having a height h.

For example:

Let the angle of repose $\phi = 32°$.
" the weight per cu. ft. of material $w = 80$ lbs.
" $h = 10$ ft. 0 ins.
" $AF = 4$ ft. 0 ins.

Then $\frac{24.58 \times 10}{2} \times 10 = 1229 =$ the horizontal pressure p_2. $2 \times 10 \times 80 = 1600 =$ vertical pressure p_1. The resultant of p_1 and p_2 gives 2017 and its point of application will be 1/3 h from the base.

If it be required to find the pressure on an inclined plane forming the lower portion of a wall as in Fig. 6, we will take the following example:

Let angle of repose $\phi = 32°$.
" weight of cu. ft. of material $w = 80$ lbs.
" $h = 15$ ft. 0 ins.
" $h_1 = 10$ ft. 0 ins.
" horizontal distance from D to $B = AF = 4$ ft. 0 ins.

Then we have the horizontal pressure at $D = 24.58 \times 10 = 245.8$ and at $B = 24.58 \times 15 = 368.7$.
Hence the total horizontal pressure on $BD = \frac{245.8 + 368.7}{2} \times 5 = 1536.25 = p_2$.

COEFFICIENTS OF EARTH PRESSURE.

θ ANGLE OF SURCHARGE θ

Degs.	φ ANGLES OF REPOSE OF MATERIAL φ 15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	Degs.
0	.5888	.5678	.5473	.5278	.5088	.4903	.4724	.4550	.4381	.4217	.4059	.3905	.3755	.3610	.3470	.3333	.3201	.3073	.2948	.2827	.2710	.2596	.2486	.2379	.2275	.2174	.2077	.1982	.1891	.1802	.1716	0
1																															.1716	1
2		.5700		.5297		.4926		.4562		.4228		.3913		.3618		.3339		.3078		.2833		.2600		.2382		.2177		.1985		.1804	.1718	2
3																															.1720	3
4		.5767		.5351		.4964		.4598		.4258		.3950		.3659		.3341		.3094		.2845		.2611		.2390		.2181		.1992		.1811	.1723	4
5																															.1728	5
6		.5885		.5445		.5039		.4662		.4311		.3983		.3694		.3390		.3120		.2868		.2633		.2409		.2210		.2004		.1821	.1733	6
7																															.1739	7
8		.6006		.5587		.5164		.4755		.4387		.4047		.3729		.3435		.3150		.2900		.2659		.2432		.2220		.2021		.1835	.1747	8
9																															.1755	9
10		.6331		.5790		.5312		.4890		.4492		.4134		.3768		.3495		.3210		.2944		.2696		.2464		.2247		.2044		.1856	.1765	10
11																															.1776	11
12		.6727		.6076		.5530		.5055		.4631		.4246		.3896		.3573		.3275		.2999		.2742		.2503		.2281		.2073		.1874	.1788	12
13	.7481																														.1801	13
14	.8923	.7377		.6494		.5832		.5285		.4812		.4382		.4015		.3671		.3357		.3068		.2800		.2552		.2322		.2109		.1910	.1815	14
15	.9659	.7932	.7214																												.1831	15
16		.9613	.7842	.7474		.6208		.5598		.5050		.4580		.4165		.3802		.3488		.3214		.2971		.2756		.2563		.2388		.2228	.1840	16
17			.9563	.7753	.7072																										.1868	17
18				.9511	.7066	.6970		.6046		.5372		.4824		.4356		.3948		.3584		.3255		.2956		.2683		.2432		.2201		.1989	.1888	18
19					.9455	.7508	.6869	.6708	.6667	.5830		.5151		.4665		.4142		.3739		.3381		.3069		.2776		.2504		.2262		.2040	.1909	19
20						.9397	.7476	.7382	.7288	.6506	.6484	.5616		.4936		.4302		.3834		.3537		.3186		.2873		.2589		.2333		.2090	.1935	20
							.9336	.9272	.9205	.7194	.7666	.6361		.5404		.4724		.4184		.3731		.3341		.2998		.2692		.2417		.2168	.1960	21
										.9136	.9063	.6968	.6290	.6157		.5194		.4514		.3979		.3779		.3339		.2964		.2637		.2348	.1990	22
												.8088	.6963	.8910	.6054	.5956		.4984		.4309		.3779		.3339		.2964		.2637		.2348	.2019	23
													.8910	.8850	.6701	.6601	.5846	.5741		.4776		.4165		.3582		.3151		.2784		.2465	.2052	24
															.8746	.8660	.6498	.6394	.5636	.5531		.4567		.3904		.3389		.2908		.2465	.2088	25
																	.8572	.8481	.8387	.8290	.8192	.8318	.5971	.5163	.4965	.4887	.4778	.3946		.3311	.2918	26
																					.5424	.6077	.8060	.5783	.5643	.5531	.5419	.4668	.4558	.3654	.2988	27
																								.7886	.7772	.7660	.7547	.5991	.5191	.4448	.3214	28
																												.7431	.7314	.6272	.3404	29
																														.7198	.3638	30
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θ ANGLE OF SURCHARGE θ

*552 West 23d St., New York City.

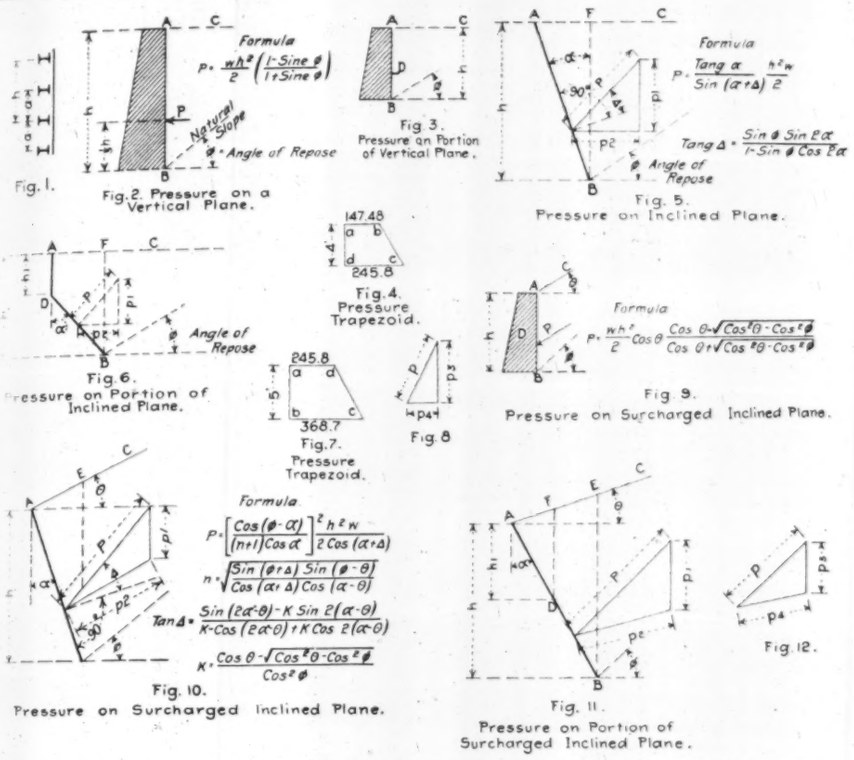


Fig. 1. Fig. 2. Pressure on a Vertical Plane. Fig. 3. Pressure on Portion of Vertical Plane. Fig. 4. Pressure Trapezoid. Fig. 5. Pressure on Inclined Plane. Fig. 6. Pressure on Portion of Inclined Plane. Fig. 7. Pressure Trapezoid. Fig. 8. Fig. 9. Pressure on Surcharged Inclined Plane.

Fig. 10. Pressure on Surcharged Inclined Plane. Fig. 11. Pressure on Portion of Surcharged Inclined Plane. Fig. 12.

FORMULAS AND DIAGRAMS FOR EARTH PRESSURE ON RETAINING WALLS.

The area of the trapezoid $ADBF = 50$ sq. ft. Therefore $50 \times 80 = 4{,}000 =$ the total vertical pressure on $BD = p_1$.

The resultant of these two forces p_1 and p_2 will give the amount and direction of pressure on the plane BD. In this case $P = 4{,}284$. The pressure trapezoid $abcd$ (Fig. 7), by finding the center of gravity, gives the point of application of the resultant as in the previous example.

The preceding example may also be solved by first finding the rate of pressure increase per vertical foot, from which the pressure on any portion of the plane may be found as follows (Fig. 8):

Let s = Angle that the plane BD makes with the vertical.

Let p = Pressure increase per vertical foot.

Then $p_3 = w \tan s$ and $p_4 = wC$.

In the above example $p_3 = 0.8 \times 80 = 64$ and $p_4 = 80 \times 0.3073 = 24.58$.

The resultant of these two forces p_3 and $p_4 = p = 68.55$.

The distance from the surface of the ground to the middle point between B and $D = 12.5$ ft. Therefore $68.55 \times 12.5 = 856.8 =$ average pressure per vertical foot on the plane BD. $856.8 \times 5 = 4{,}284 =$ the total pressure on BD for one foot of length. The direction of this resultant will be parallel to p (Fig. 8).

Surface of the Ground AC at any Slope

If it be required to find the total pressure on a vertical plane AB when AC, at any angle, is the surface of the ground, let (Fig. 9):

θ = Angle of surcharge, i. e., angle which surface makes with the horizontal.

C = Coefficient for the angles ϕ and Θ.

Then $P = \dfrac{wh^2}{2} C$.

P will be parallel to AC and applied at $\frac{1}{3}\ h$ from the bottom.

If it be required to find the pressure on a portion of the face AB as DB in Fig. 9, the method is as follows:

For an example:

Let $\phi = 32°$.
$\theta = 20°$.
$w = 80$ lbs.
$h = 10$ ft. 0 ins.
$BD = 4$ ft. 0 ins.
$wC = 80 \times 0.3739 = 29.91$.
$29.91 \times 6 = 179.46 =$ pressure per vertical foot at D.
$29.91 \times 10 = 299.1 =$ pressure per vertical foot at B.

$\dfrac{179.46 + 299.1}{2} = 239.28$ average pressure per vertical foot on BD.

$239.28 \times 4 = 957.1 =$ total pressure on BD per foot of length.

The direction of the resultant is parallel to AC. Again by the trapozoid method the point of application of the resultant may be found.

The Plane AB Inclined.

In Fig. 10 we are required to find the pressure on the plane AB when AC, the surface of the ground, is at any angle.

First find as previously the force p_2 which is parallel to AC and the vertical force p_1. By combining p_1 and p_2 we get the amount and direction of the resultant force on AB. The vertical force p_1 is the weight of material vertically above AB, i. e., the triangle ABE. The force p_2 is the same as that on a vertical plane having a height BE.

As an example we will let:

$\phi = 32°$.
$\theta = 20°$.
$\alpha = 16°$.
$w = 80$ lbs.
$h = 10$ ft. 0 ins.

Then $BE = 11.04$ ft.

$\dfrac{29.91 \times 11.04}{2} \times 11.04 = 1{,}823 =$ force p_2.

The area of the triangle $ABE = 15.83$; therefore $15.83 \times 80 = 1{,}267 =$ vertical force p_1. The resultant of forces p_1 and $p_2 = P = 2{,}550$, the total pressure on AB. The point of application of the resultant pressure will be at a height of $\frac{1}{3}\ h$ above the base.

For finding the pressure on any portion of the inclined plane as DB, Fig. 11, when AC, the surface of the ground, is at any angle, let:

$\phi = 32°$.
$\theta = 20°$.
$\alpha = 16°$.
$w = 80$ lbs.
$h = 10$ ft. 0 ins.
$h_1 = 5$ ft. 0 ins.

Then $BE = 11.04$ and $DF = 5.52$.

$29.91 \times 5.52 = 165.1 =$ pressure per vertical foot at D.

$29.91 \times 11.04 = 330.2 =$ pressure per vertical foot at B.

$\dfrac{165.1 + 330.2}{2} \times (11.04 - 5.52) = 1{,}367 = p_2$.

p_2 is parallel to AC.

The weight of material vertically over $BD =$ trapezoid $BEFD = 11.87 \times 80 = 949.6 =$ vertical force p_1. The resultant of these two forces p_1 and $p_2 = P = 1{,}912 =$ the total pressure on BD for one foot of length. The trapezoid of forces will give the point of application as previously explained.

The preceding case may also be solved as follows: first find the rate of pressure increase per vertical foot from which the pressure on any portion may be found as follows; let:

p = rate of increase of pressure per vertical foot.

Then $p_4 = w \times$ coefficient of ϕ and θ and is parallel to AC.

And $p_3 = \dfrac{w}{\cot \alpha + \tan \theta}$ and is vertical.

In the above problem, $p_4 = 29.91$ and $p_3 = 20.77$ and hence the resultant $p = 41.84$ (Fig. 12).

The average vertical depth of B and D from the surface of the ground $= 8.28$ ft. Therefore $41.84 \times 8.28 = 346.4$. $BE - DF = 5.52$. Hence $346.4 \times 5.52 = 1{,}912 = P =$ total pressure on BD. The direction of the resultant will be parallel to p, Fig. 12.

Civil Service Examination for Civil Engineer in the Philippine Service.

[By a Correspondent.]

Below are given the questions of the civil service examinations held March 8-9, 1911, for Civil Engineer in the Philippine Service. The writer took the examination and wrote down the questions afterward from memory. The correctness of the questions was verified by two other men who had taken the examination. The time for the whole examination was nine hours—six hours the first day and three the second day—divided among the three subjects, as indicated below. The relative rating or weight of the subjects, on a scale of 100, was: Mathematics, 20; Use and Construction of Instruments and Surveying, 30; Design and Construction, 25; Training and Experience (taken from application blank), 25.

MATHEMATICS.—Time 2½ hrs. Answer any three of the questions.

1. The sides of a triangle are 27, 36 and 44. Find the length of the line joining the longest side to the vertex of the opposite angle.

2. What load per foot, in a beam 20 ft. × 8 ins. × 3 ins., will produce the same bending moment as that of a cantilever beam 8 ft. × 6 ins. × 4 ins., with a load of 200 lbs. placed 2 ft. from the free end?

3. Using the formula $V = 117\sqrt{R\,S}$ with a pipe 2 ft. in diameter, running 18 ins. deep at the center and a slope of 1 in. in 200 ft., find the discharge in cu. ft.

4. The radii of the frustum of a cone are 5 ins. and 17 ins. The height is 9 ins. Find the area of lateral surface and the solidity.

USE AND CONSTRUCTION OF INSTRUMENTS, AND SURVEYING.—Time 3½ hours. Answer any four questions.

1. Give all necessary precautions for accurate measuring with a steel tape.

2. Explain in detail how to find the true meridian for any given station with an engineer's transit.

3. Explain the principles of stadia measurement, and tell how to find the constants in the formula $(D = Ks + f + c)$ in any case.

4. At a station from which three plotted points are visible, tell how you would locate the station on the plane table.

5. Explain fully two different ways of making the bubble tube parallel to the line of collimation.

DESIGN AND CONSTRUCTION.—Time, 3 hrs. Answer any three of the questions. Make freehand pen sketches whenever possible.

1. Name the common defects in yellow pine. Explain each and give method of detecting.

2. Explain and show details of a timber bridge (span, 35 to 40 ft.), so that it will carry ordinary road traffic.

3. Design and show details of a reinforced-concrete floor slab 30 ft. × 20 ft., with a uniform load of 250 lbs. per sq. ft., and give factors of safety used.

4. Name necessary tests for Portland cement. Explain each in detail.

Water-Supply and Sewerage of the National Rifle Range, Camp Perry, Ohio.

By R. WINTHROP PRATT,* M. Am. Soc. C. E.

In 1906 the State of Ohio, through its National Guard, in order to promote rifle practice, purchased a tract of land covering some 600 acres located on the shore of Lake Erie about four miles west of Port Clinton, Ohio. Cooperatively with the United States Army, the state has developed this land and changed it from an unattractive marsh into a fine park and camp ground with permanent buildings, and has named it Camp Perry. Each season this place is the scene of shooting contests, not only between members of the Ohio National Guard, but also between representatives of the militia of various states of the Union, and of the U. S. Army and Navy. In addition, Camp Perry serves as a place for instruction camps for the state militia.

The population, including visitors, amounts to at times from 3,000 to 4,000, although the average for the season is only 1,500. The water consumption is about 100,000 gals. per day. This varies, of course, with the population, but the variation is not as marked as might be expected for the reason that a large proportion of the water is used to supply the automatic flush tanks in the water-closets, which tanks discharge at regular intervals regardless of their use. The sewage flow amounts to 100,000 gals. daily and for the above reason is fairly constant, except when increased by leakage due to heavy rains.

Surface Drainage.

The topography of the site of the camp is very flat, there being less than 6 ft. difference in elevation between the highest and lowest points of the entire 600 acres. This feature, while very favorable for long-range rifle shooting, is very unfavorable from the standpoint of easy drainage, especially as much of the land is below the average level of the water in Lake Erie. The soil is a heavy clay. The method by which the land was kept dry enough for crop raising by the farmers who previously owned it was by draining through open ditches into a pool or shallow basin from which the water was raised into Lake Erie by means of a "water elevator." Briefly, this device consisted of a series of wooden paddles, attached to endless chains which pushed the water up an inclined plane. The motive power was sometimes a gas engine and sometimes a horse operating a windlass.

One of the first improvements was to enlarge the drainage ditches, substituting tile pipe therefor in certain places, and to enlarge the receiving pool or drainage basin, making the same 800 by 50 ft. by 7 ft. deep, so that in ordinary weather it would hold several weeks' flow of surface and ground water. Also, a 20-in. low-lift centrifugal pump and 16-HP. gas engine were installed in place of the wooden water elevator. By pumping out the basin when the wind and lake currents are from the east, all possibility of contamination of the Camp Perry water-supply from this source may be prevented.

*Chief Engineer of Ohio State Board of Health, Columbus, Ohio.

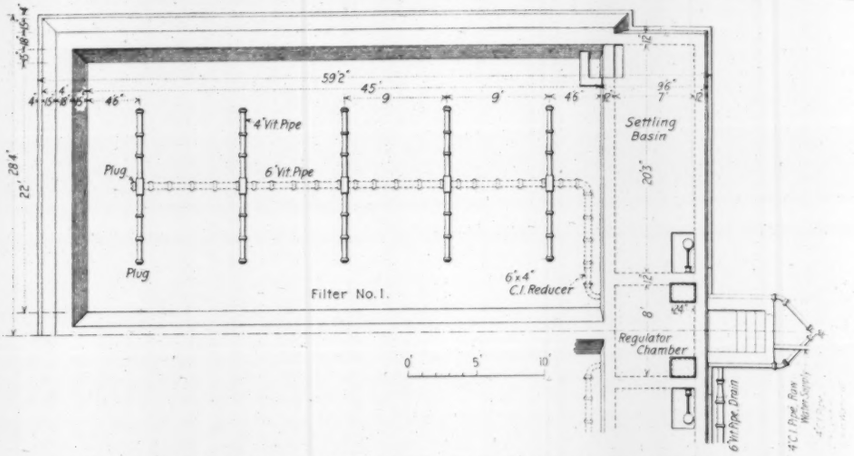


FIG. 2. HALF-PLAN OF SLOW SAND WATER-FILTERS, WITH SETTLING BASINS, AND REGULATOR CHAMBER, CAMP PERRY, OHIO.

Sewerage and Sewage Purification.

The great majority of the population at Camp Perry sleep in tents; and for the use of these men there have been erected, at convenient locations, ten toilet buildings or latrines, each containing about twenty water-closets and urinals. The drainage from these latrines, as well as from other water-closets located in the officers' headquarters buildings, mess hall, general office, and club house, is conveyed to a collecting well through a sanitary sewerage system having a total length of about 20 miles of 6, 8, and 10-in. vitrified pipe. It was necessary to use very flat grades, that of the 10-in. line being 0.2%, and that of the 6-in. line, 0.3%.

The collecting well, located near the power house and pumping station, is 15 ft. in diameter and 12 ft. deep. The inlet sewer discharges through a coarse "basket" screen at a depth of about 4 ft., or 2 ft. above the inlet sewer; the contents, amounting to about 5,000 gals., plus the sewage entering during the pumping period, are pumped by a 4-in. centrifugal pump to the purification plant. The force main is 6 ins. in diameter and 500 ft. long, and the lift is 7 ft. In dry weather the pumping periods are about 15 minutes each, with 45-minute intervals between pumping, while in wet weather, due to a great amount of leakage into sewers, it is sometimes necessary to pump continuously for hours at a time.

The purification plant consists of four sand filters (Fig. 1), each 70 ft. square, thus giving a total area of one-half acre. Preliminary tank treatment was omitted in order that the sewage might reach the filters in as fresh a condition as possible, and thus obviate offensive odors. The filters are placed on top of the original ground surface and enclosed with rolled embankments of clay. In the center of the group of filters is a screen and distributing chamber into which two force mains discharge and from which the screened sewage may be diverted to the filters as desired. The screen consists of parallel iron bars with open spaces of ¾-in.

The filters are underdrained by three lines of 6-in. vitrified tile, 22 ft. apart, placed in wide depressions or valleys, the bottoms of which are 6 ins. below the tops of the ridges between them. Over the drains was placed a 6-in. layer of broken stone and above that a 2-in. layer of fine gravel, upon which was placed 3 ft. of sand, taken from the nearby beach. Analysis of this sand showed an effective size of about 0.20 mm., and an uniformity coefficient of 2. It will be noted that, based on the usual practice in intermittent sand filtration plants, the area here provided is very small, being, with the maximum population, in the proportion of 8,000 persons to the acre instead of 1,000 to 1,500; although, due to the very strong sewage, the average rate of filtration is not more than 200,000 gals. per acre per day. The design seemed warranted, however, by the fact that the filters were to be used only in the hottest weather, when bacterial activity is greatest; and also because the periods of maximum tributary population were very short, being a week or two. Of course, the small area makes necessary very frequent cleaning when the maximum population is using the sewers. In spite of this it has been possible, with plenty of labor and with ample disinfection of the effluent, to get along for several seasons, before all the filters were finished, with only two filters or ⅛-acre.

The sand-filter effluent is treated with chloride of lime and then passed into the same collecting pool or basin which receives the surface drainage of the grounds, and from which the water is periodically pumped into Lake Erie. Disinfection of the sewage effluent was made desirable by the fact that the water-supply is drawn from the lake about 1,000 ft. from the point of discharge of the pump which drains the collecting basin.

The disinfection plant consist of a concrete weir box inserted on the main drain near the outlet. Above the weir box is a 120-gal. elevated concrete storage tank, cubical in form, in which the solution of chloride of lime is mixed and stored. The tank drains into an orifice box, provided with a rectangular adjustable orifice,

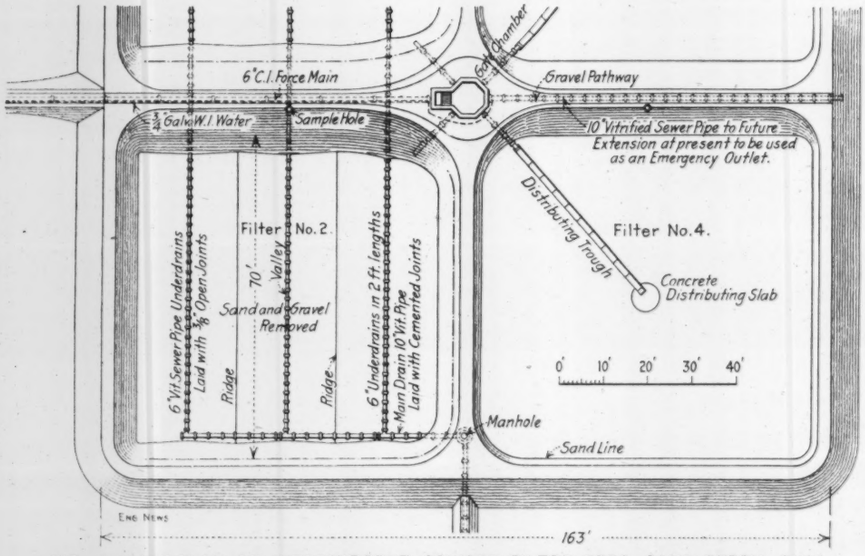


FIG. 1. HALF-PLAN OF INTERMITTENT SEWAGE FILTER BEDS, CAMP PERRY, OHIO.

the head on which is kept constant by means of a float valve on the inlet pipe.

Water-Supply and Water Filtration.

It being impossible to obtain a ground water-supply, the water for the camp is taken from Lake Erie and filtered through a slow sand filtration plant.

The intake consists of a 6-in. galvanized-iron pipe extending into the lake some 800 ft., where the water is about 6 ft. deep. The shallowness of the lake in this vicinity causes the water to become quite turbid with every storm. At the shore line the galvanized-iron intake pipe connects with the 6-in. cast-iron suction line, extending to the power house, 600 ft. back from the lake. Here a 3-in. centrifugal pump raises the water into the filtration plant.

This plant (Fig. 2) consists of: (1) two settling basins, each 20 × 7 ft. by 7 ft. deep, and having a combined capacity of 15,000 gals. or about two hours' flow at the usual rate of filtration; (2) two filters each 45 × 22 ft., having a combined area of 2,000 sq. ft., or 0.046-acre; (3) a control chamber; (4) a covered circular clear water basin, 25 ft. in diameter and 8 ft. deep, holding 28,500 gals. Concrete was used for the filter walls and associated structures.

The settling basins and filters extend about 6 ft. above the level of the ground. As a matter of convenience in handling filter sand, the basins were covered with a concrete roof, although the filters themselves, being for summer use only, were not covered.

The filtering material consists of: (1) a 12-in. layer of gravel or clean broken limestone of three different grades or sizes, the lowest being 1 to 2 ins., the next ¼ to 1-in., and the third 1/16 to ¼-in.; and (2) 3 ft. of sand. One of the filters contains local beach sand having an effective size of 0.23 mm., an uniformity coefficient of 1⅛, and contains some very fine material. The other filter contains washed bank sand from Michigan, which is somewhat coarser, more free from fine material, and more uniform. Each filter is underdrained by a 6-in. tile pipe below the floor and lateral lines of 4-in. channel pipe laid inverted upon the floor.

The control chamber (Fig. 3) is located between the two settling basins and under the same roof. It is only 7 × 8 ft. in plan, but is worthy of mention in that it contains, compactly arranged, all the valves necessary for the operation of the basins and filters, loss-of-head gages (Fig. 4), and two small Venturi meters with mercury gages to indicate the rate of filtration.

On account of the proximity of the beach sand, it was considered cheaper to replace the dirty sand with new sand when necessary. No sand-washing devices were, therefore, provided. This system may not prove economical, however, in view of the fine material in the beach sand and the consequent necessity for frequent cleaning. When clogged, the filters are scraped by laborers with flat shovels, and the soiled material thrown away. In order to quickly drain the water from the surface of the sand, previous to scraping, there was used a piece of 3-in. wrought-iron pipe, in the shape of a siphon, which was placed across the entrance weir between filter and sedimentation basin, and which drew the water off through the latter.

Power House and Pumping Equipment.

The power house is a wooden structure 25 × 36 ft., in which are located a 4-in. Brook's centrifugal sewage pump of 450 gals. per min. capacity; a 3-in. Brook's centrifugal raw-water pump of 300 gals. per min. capacity; a Weinman horizontal double-acting belt-driven high-service pump having a 12-in. cylinder and a 12-in. stroke; and one General Electric Co.'s 40-KW. generator for lighting purposes, supplying 160 amperes at 250 volts. The 4-in. and 3-in. centrifugal pumps are placed in pits which are 12½ ft. and 8½ ft. deep, respectively. The high-service pump takes the filtered water from the clear well through a 6-in. suction pipe 25 ft. long and forces it into the stand-pipe and distribution system. All pumps as well as the generator are driven by one horizontal single-cylinder 60 HP. gasoline engine, manufactured by the Columbus Machine Co.

DISTRIBUTION SYSTEM.—A 75,000-gal. steel stand-pipe, 16 ft. in diameter and 50 ft. high, is located near the power house. This affords a pressure of from 25 to 30 lbs.; while by direct pumping a 50-lb. pressure can be secured. This distribution system consists of 6-in. and 4-in. cast-iron pipe and 2-in. galvanized-iron pipe. The total length is 5½ miles, of which the galvanized pipe comprises about 75%.

COSTS.—The approximate costs of certain parts of the work are as follows:

Water-filtration plant	$6,000
Stand-pipe	1,500
Power-house and equipment	3,700
Sewage-disposal plant	3,000
Engineering and inspection	1,500

Some of the principal unit prices bid by the contractor who constructed most of the work were:

Concrete in walls	$9.50 per cu. yd.
Concrete in roof	8.00 per cu. yd.
Sand filtering material for water filters	.70
Sand filtering material for sewage filters	.60

Operation and Efficiency of Water Filtration Plant.

During the three seasons since both filters have been completed this plant has invariably produced a water of excellent appearance and usually one which was hygienically safe.

The turbidity of the raw lake water varies from about 15 to 150 parts per million, while that of the filtered water has always been zero. The total number of bacteria in the raw river water usually varies from 100 to 2,000 per cc., although sometimes the number is considerably greater. The number in the filtered water averages about 38. During the season of 1908, the filtered water contained B. coli several times; but during 1909, owing, probably, to obtaining a better raw water, this type of bacteria has been invariably absent in the filtered water.

A summary of the analytical results obtained during 1908 and 1909 is given in Table I.

TABLE I.—ANALYTICAL RESULTS OF CAMP PERRY WATER-FILTRATION PLANT DURING THE SEASONS OF 1908 AND 1909.

	Raw water.	Effluent filter No. 1	Effluent filter No. 2
SEASON OF 1908.			
Total number of samples	15	15	15
Average total numbers of bacteria	940	50	60
Number of samples containing B. coli in 1 c. c.	3	0	0
Number of samples containing B. coli in 50 c. c.	6	3	6
SEASON OF 1909.			
Total number of samples	14	14	14
Average total numbers of bacteria	430	27	16
Number of samples containing B. coli in 10 c. c.	3	0	0
Turbidity (parts per million)	60	0	0

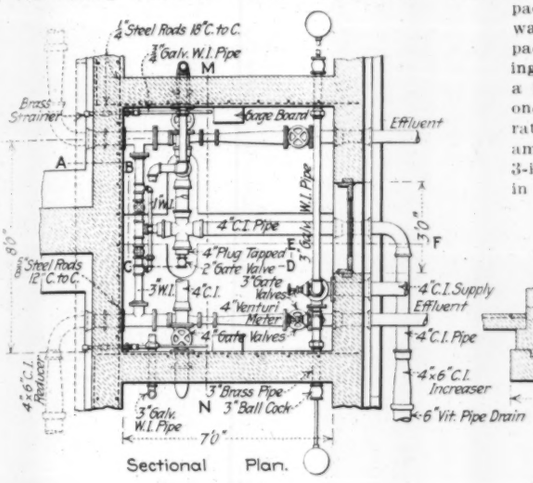
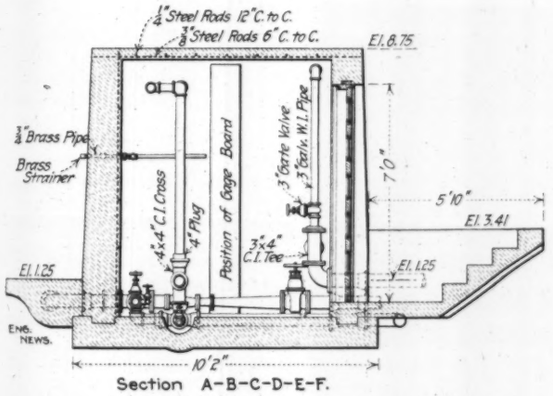


FIG. 3. REGULATOR CHAMBER, SLOW SAND WATER-FILTERS, CAMP PERRY, OHIO.



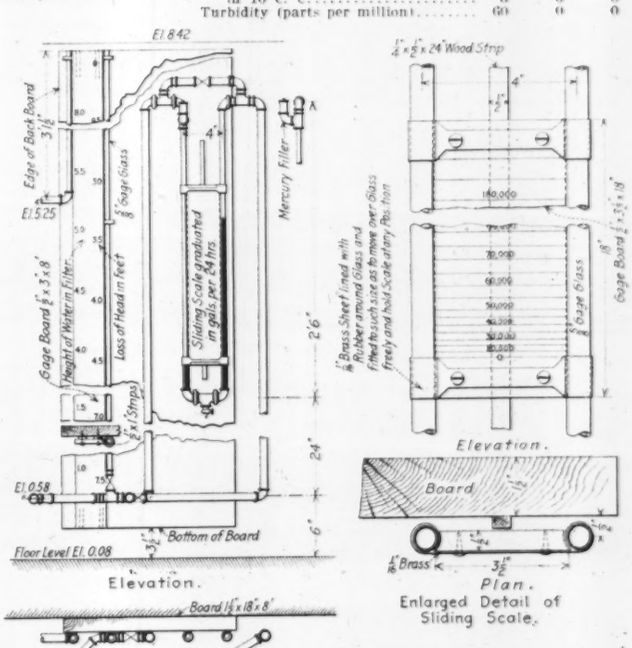


FIG. 4. LOSS-OF-HEAD GAGES, SLOW SAND WATER-FILTERS, CAMP PERRY, OHIO.

The analytical work was done on the ground, under the direction of the State Board of Health, by the superintendent of the plant, a young engineering graduate. Check samples were also shipped to the Board's laboratory at Columbus.

It is believed that with a greater settling basin capacity, say 12 hours instead of 2, better bacterial efficiency could be obtained. Referring to the presence of B. coli in the filtered water in 1908, it may be noted that the samples were taken each time directly after cleaning the filter; and that the high turbidity of the raw water and the short sedimentation period caused the filters to require washing frequently, as will be discussed below.

As stated above, the average daily water consumption at Camp Perry is 100,000 gals.; it being 74,500 in 1908 and 111,300 in 1909. The maximum daily consumption is 150,000 gals. The average rate of filtration, during the 16 hours per day of operation, is about 4,000,000 gals. per acre daily. To supply the maximum demand, an increase is sometimes made for a day or two at a time to a 6,000,000-gal. rate; but the filters are never operated during the entire 24 hours.

Table II. contains a summary of the records of operation for 1909. The greater frequency of cleaning necessary with Filter No. 1 is doubtless explained by the smaller effective size of this sand, as well as by the existence in the sand, as above mentioned, of a considerable amount of very fine material. The time necessary for the scraping and removal of the dirty sand, at each cleaning with two men working, is about two hours; but two or three hours more are necessary to refill the filter with pure water from below, before filtration can be started again.

TABLE II.—CAMP PERRY WATER-FILTRATION PLANT: SUMMARY OF RECORDS OF OPERATION JULY 23 TO SEPT. 12, 1909.

	Filter No. 1.	Filter No. 2.	Average or total
No. days in operation	51	52	.....
No. hours in operation	781.5	829.5	.....
Ave. no hours daily	15.3	16.0	.....
Av. rate of filtration M. G. D. per acre	3.65	3.88	3.76
Av. quantity filtered daily	53,730	58,675	112,405
Av. No. days between cleanings	5.4	7.6	.....
Av. No. hours of operation between cleanings	82	131	.....
Av. quantity filtered between cleanings (gals.)	291,000	484,000	337,006
Max. quantity filtered between cleanings (gals.)	458,000	693,000	.....
Min. quantity filtered between cleanings (gals.)	82,000	364,000	.....

Operation of Sewage-Disposal Works.

Referring to the difficulties which have developed during the operation of the plant, the most serious one has been the clogging of the centrifugal sewage pump due to large material passing by the screen at inlet to pump well. Such clogging has occurred twice (the first time being due to a pair of overalls which had been thrown into the sewers), and has caused the sewage to back up almost into the latrines. Another trouble was poor distribution over the filters due to operating the pump at too slow a speed.

Of course the very high rates of filtration, about 300,000 gals. per acre per day of strong sewage, has made frequent cleaning necessary; in fact it has taken about all the time of one laborer to keep the surface of the sand sufficiently porous to pass the sewage.

The final treatment of the sand-filter effluent by disinfecting it with chloride of lime is of great advantage as a precaution against polluting the lake in the general vicinity of the water intake. This disinfection results in reducing the total numbers of bacteria from several million to 100 or 200 per cc. (the high count being due to the strength of the original sewage and the high rates of filtration).

Table No. III. gives an indication of the frequency of removal of B. coli. The chloride of lime, containing about 30% available chlorine, is purchased in 10-lb. cans and used at the rate of 15 to 20 lbs. per day, representing 6 to 8 parts per million of available chlorine. The average daily cost of chemical was 75 cts.

TABLE III.—CAMP PERRY SEWAGE WORKS: REMOVAL OF B. COLI FROM SAND FILTER EFFLUENT BY DISINFECTION.

	Before treatment.	After treatment.
SEASON OF 1908.		
No. of samples	13[1]	13[2]
B. coli present in	13	2
SEASON OF 1909.		
No. of samples	14[3]	14[4]
B. coli present in	14	5

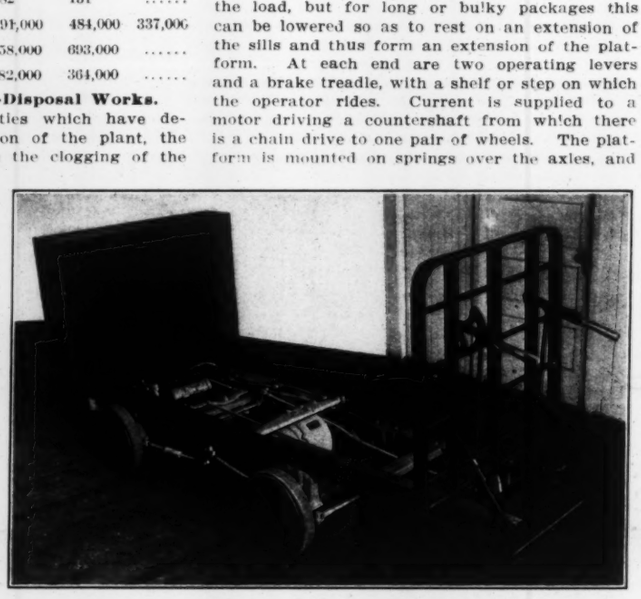
[1].001 cc. samples. [2]Chiefly 50 cc. samples. [3]Chiefly .00001 cc. samples. [4]10 cc. samples.

The works were, in general, designed by the writer and constructed under his direction. The Pitt Construction Co., of Pittsburg, Pa., was the contractor; and Mr. C. L. Wilcox of that company designed the loss-of-head and rate gages.

Electric Trucks for Handling Baggage and Freight.

A new development in mechanical methods of handling freight, etc., is the use of light motor trucks to replace the ordinary hand truck for transporting baggage and freight at railway stations, freight houses and steamship piers; such trucks are adaptable also for use at warehouses, manufacturing and storage plants, and similar establishments where freight has to be moved from place to place and in relatively small quantities. Motor trucks for this class of service have been described recently in our issues of April 13 and May 11, 1911, and another form of storage battery truck is shown in the accompanying cut.

This truck has a steel frame mounted on four wheels, and carrying at one end a steel battery box. At the other end is a steel gate to retain the load, but for long or bulky packages this can be lowered so as to rest on an extension of the sills and thus form an extension of the platform. At each end are two operating levers and a brake treadle, with a shelf or step on which the operator rides. Current is supplied to a motor driving a countershaft from which there is a chain drive to one pair of wheels. The platform is mounted on springs over the axles, and



STORAGE BATTERY TRUCK FOR HANDLING FREIGHT AND BAGGAGE: PLATFORM REMOVED TO SHOW MECHANISM).
(The Automatic Transportation Co., Buffalo, N. Y.; Builder.)

these, with the broad rubber tires on the wheels ensure easy and noiseless movement. In the standard size, the platform is 7 × 3½ ft., or its length may be increased to 10 ft. by lowering the end gate. The wheels are 16 ins. diameter, with a gage of 3 ft. and a wheelbase of 4 ft. 2 ins. In the freight truck, the platform is 20 ins. above the floor; but for trucks handling baggage, mail and express matter this is increased 3 ft. by an upper deck; the movable end gate however, is retained. Special sizes can be m... required.

The battery consists of 24 cells, with ... pacity of 56 amperes for four hours. The ... is of 3 HP., and will stand an overload of 100% so that it is said the truck can carry ... of one ton up a grade of 20%. The sp... from 2 to 10 m.p.h. and one charge of b... 's sufficient for a day's work. The weig... the truck (including batteries) is 1,800 lbs. ... it will carry a load of 2,000 to 4,000 lbs. ... great advantage of the truck is not so mu... its load capacity as in its speed and flexi... of movement, by which it is enabled to ... loads rapidly from the receiving point to ... desired car (or other point). The truck ... run directly into a freight car to deliver ... ceive a load, so that there is no more ha... of freight than by the use of hand trucks. At the same time, the truck can carry a h... load and move much more rapidly than a ... truck.

The Erie Ry. has 20 of these electric trucks in use at one of its piers in Jersey City, where they handle about 600 tons of general merchandise freight every night. They distribute the freight from cars and barges to 85 cars placed alongside the platforms, and have to ascend inclines from the barges. We are informed that they have shown already a saving of over 30% in the cost of handling freight. These trucks are built by the Automatic Transportation Co., of Buffalo, N. Y.

Testing Trap-Rock Screenings for the Percentage of Foreign Material.

By W. S. LOZIER,* C. E.

When we specify that trap-rock screenings for road construction shall not have more than a certain percentage of foreign material, we desire to eliminate such things as slate, limestone, sand etc. How many engineers investigate the actual character of the screenings received other than through the most superficial examination? Exact tests for the percentage of foreign matter seem to be disregarded.

A short time ago, the writer was called upon to determine the percentage of foreign material in a quantity of trap-rock screenings submitted by a contractor as the material he intended to use as a binder, and after searching a good many books on the subject concluded that the point evidently had been passed over. How to make the test was then the question. A chemical test would not answer and so it was concluded to examine on a specific-gravity basis. It is well known that the specific gravity of trap rock is greater than the specific gravity of the other rocks. If a mixture of some liquid gravity could be found that would give a specific gravity which would be less than the trap rock and greater than the foreign material, the question seemed to be solved.

A solution of potassium and mercuric iodides was chosen, as it was nearly colorless and gave a specific-gravity-range from water to something higher than trap rock, according to the dilution. The screenings were introduced into the vessel containing the liquid and properly stirred so that no air would collect around the particles, and also to cause a separation of the particles so that the larger and heavier ones would not carry the lighter ones to the bottom. The vessel was then set aside for a few hours to allow all settling to take place. The heavier material or trap, was found to have settled in a compact layer on the bottom and the lighter material were floating at the top. It was then only a question of decanting off the liquid, filtering, washing, and filtering again, to determine the percentage of material that was not trap rock. To separate the foreign material into its different constituents, the process only had to be repeated with the same mixture and by the addition of more water to change the specific gravity to the desired figure.

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The location of large low-pressure cylinders on four-cylinder compound locomotives is becoming a problem with some foreign railways, and they are experiencing difficulty in providing room for low pressure cylinders of the diameter required for powerful modern locomotives. This fact was referred to in our issue of June 1, in the article on the locomotives at the Brussels exhibition. On fast engines it is very desirable to place the large cylinders (with their heavy pistons and other reciprocating weights) between the frames; if they are outside, these reciprocating weights are liable to cause nosing or swinging of the engine, while the cylinders may come very close to the clearance limits. When placed inside, the distance between the frames practically limits the cylinder diameter, although this limit may be exceeded slightly by offsetting the frames or by cutting a hole in the web of the plate frames to allow the side of the cylinder to project through it. A novel arrangement which overcomes this limitation and permits of the use of very large inside cylinders has been adopted in some large four-cylinder compound locomotives for the Northern Ry. of France. The universal arrangement of inside cylinders is to place them side by side, but in this case the engineers have departed from established precedent and practice by offsetting the cylinders longitudinally, so that the only limitation in their diameter is that of leaving room between the side of the cylinder and the frame for the piston rod and its connections. The distance between the center lines of the cylinders in this case is 15¼ ins. The front head of one cylinder and the back head of the other are cast integrally with the cylinder walls, and these heads are bolted together where they overlap. The pistons are removable through the back and front covers respectively. The piston of the cylinder nearest the axle has a tail rod sliding in a guide formed in the brace fitted between the forward cylinder and the frame. The piston of the forward cylinder has its piston rod sliding in a similar guide, so that this piston requires no tail rod. This piston rod, of course, is longer than that of the other cylinder, the connecting rods being of the same length. These inside (low-pressure) cylinders are 23¾ × 25¾ ins., while the outside (high-pressure) cylinders are 17¼ × 25½ ins. Over each outside cylinder is a single piston valve serving one pair of cylinders. The engines in question are of the 4-6-4 class, designed for high-speed service with heavy passenger trains.

It is of interest to note that an offset arrangement of cylinders was a feature of a patented design for a four-cylinder compound locomotive brought forward in this country some years ago. But in this case the arrangement was used for two outside cylinders on each side, the offset or semi-tandem arrangement being adopted in order to avoid excessive width. In this engine (which avoided the use of crank axles) the piston rod of one cylinder was connected to a crank pin in the driving wheel, while that of the other was connected to a return crank.

The annual report of the Westinghouse Electric & Manufacturing Co. to its stockholders, made public last week, contains some information of unusual interest to engineers. It is always advantageous to profit by the experience of others, but in the larger matters of corporation finance, the records of success and of failure are generally kept as confidential information. The average engineer—or the average investor for that matter—knows little of what is going on behind the scenes in a corporation that he works for or in which he holds stock. The Directors of the Westinghouse Electric & Manufacturing Co. have done an important public service by their present publication concerning the company's experience in certain of its important ventures.

In an ordinary manufacturing business, it is a well-established principle that the product should be sold either for cash or for notes which can be converted into cash. In the electrical manufacturing business, however, from its earliest history this common rule of business has been largely ignored. The largest customers of the electrical companies are the concerns which build electric light plants, electric railways and electric power plants. Substantially all these concerns during their construction period are seeking capital, and generally are seeking it very earnestly. Most of these concerns, therefore, have bought their machinery from the company which would accept the largest amount of the purchase price in bonds and stocks instead of in cash. This policy has partially been forced upon the electrical companies by the competition which has prevailed; but to a certain extent it has been fostered by them. Interests more or less closely identified with the great manufacturing companies have engaged in the promotion of railways, lighting plants and hydro-electric schemes.

A manufacturing business is one thing. The carrying on of an investment business and supervising the management of railways and lighting plants scattered in different parts of the country, so as to secure efficiency and honesty in their operation, is another and totally different line of work.

In the fiscal year ending March 31, 1911, the Westinghouse Co. made a net profit on its manufacturing business of $5,600,000, and the factory plants it owns are valued at about $17,600,000. During the same year it received $615,000 income from its investments, which investments are valued on its books at about $24,000,000. It is fair to say, however, that the capital in use by the company to earn its manufacturing profit includes current working capital, raw materials, finished goods, etc., valued at some $35,000,000, besides the investment in its factories.

There has been hitherto very little made public regarding the character of the investments made by the electrical manufacturing companies and their results. In this report, a frank and illuminating statement is made as to what this twenty-four odd million dollars of investments made by the Westinghouse Co. represents. It may be noted from the face of the figures that the income which the company received from its investments last year represented only about 2½% on the above book valuation. It need hardly be said that the actual present value of these assets, therefore, if based on what they could be sold for, is very much less than the $24,000,000 at which they are listed. Of course, the company is carrying these various investments at an admittedly high valuation in the hope that, as the various properties become established and profitable, the market value of their securities may be established and the stocks and bonds which the company holds may be sold at their present valuation.

One of the companies in which the Westinghouse Co. has a very large interest is the Lackawanna & Wyoming Valley Rapid Transit Co., of which the Westinghouse Co. holds bonds with a face value of $6,174,000 and stock with a par value of $4,885,600. The history of this property is of especial interest in connection with the controverted question as to the advantages or disadvantages of electricity over steam in regular railway operation. The Lackawanna & Wyoming Co. constructed half a dozen years ago, an electric interurban railway line between Wilkesbarre and Scranton, Pa., about 22½ miles long. The road was built in a first-class manner and is operated electrically with a third rail. The total cost of building and equipping the railway was in round numbers $7,100,000, or about $315,000 per mile of double track.

The Westinghouse Co. furnished nearly all the capital for the construction and equipment of this road, and it was understood at the time that it did this not merely to secure a market for electric apparatus, as in the financing of other electric properties, but to demonstrate the great advantage of electricity over steam in interurban service, expecting thereby to establish a large market for the sale of its apparatus.

In actual operation, however, the road has been a huge financial failure. Its percentage of operating expenses to earnings is low, but the cost of the road was so great that its net earnings have never been sufficient to pay the interest on its bonds. In other words, instead of demonstrating the advantage of the third rail electric system for interurban service, what has actually been demonstrated is that in this case, at least the high cost of electrical construction does not yield any return in reduced operating expenses sufficient to justify capital in undertaking such investments.

The stock of the Lackawanna company is admittedly worthless, the entire amount owned by the Westinghouse Co., nearly $5,000,000 in par value, being carried on its books at a valuation of $1. The directors of the Westinghouse Co., in view of the existing state of affairs, have written off to profit and loss $2,000,000 of the book value of the Lackawanna bonds. They hope that with this reduction the company may eventually be able to dispose of the road for enough to realize the remaining valuation.

No estimate is made of the total amount which this investment has actually cost the Westinghouse Co., but it is evident that to the $2,000,000 now written off must be added the deficiency in interest during the years since the road was in operation and any eventual failure to realize the present book value. It looks very much as if the total loss of the company in this unfortunate third-rail demonstration might reach from $3,000,000 to $4,000,000.

A considerable part of the Westinghouse Electric Co's $24,000,000 of investment assets is made up of stocks and bonds in various Westinghouse companies which have been organized for the manufacture of Westinghouse apparatus in foreign countries. Several of these concerns are of very large size and have attracted world-wide attention. It now appears, however, that most of them have proved losing ventures for the parent company.

The Westinghouse Electric Co., Limited, of Great Britain, is a concern organized to exploit Westinghouse patents in foreign countries. It has a capitalization of over $2,000,000, but its income is and has long been insufficient to pay its expenses. About $1,300,000 of the investment in this company has already been written off to profit and loss, and it is frankly stated

that further losses will probably have to be accepted.

The British Westinghouse Electric Co., which built and has operated for nearly ten years an enormous manufacturing establishment near Manchester, England, had originally a total capitalization of nearly $22,000,000, of which over $18,000,000 was actually invested in creating the works and their equipment. The company's business in the years from 1904 to 1908, inclusive, never yielded sufficient profits to pay its fixed charges. In 1909, for the first time, the company earned a profit over its fixed charges of $21,000 and increased it to $87,000 in 1910.

The American Westinghouse Co. invested about $4,500,000 in the preferred stock of the British company, and a year ago about $3,500,000 of this sum was written off to profit and loss. While at present the British company is thought to have better prospects of success, it is stated that further reduction of its capital must be contemplated.

A French Westinghouse company was organized in 1901 and has a capital of nearly $6,000,000. In every year since 1906, with one exception, the company has not earned its interest charges. The directors hope that eventually the investment in the French company may be realized on, but at present its securities have no market quotation.

The Westinghouse Co., of Italy, built a factory in 1907-8 in the hope of securing important contracts to electrify part of the Italian State Railways. This hope has not been realized, and the company has barely earned its interest charges since it began operations.

The Russian Westinghouse Co., organized in 1906, primarily to carry out a contract for electrifying the St. Petersburg street railways, has also been unsuccessful. The execution of the contract resulted in a loss of over $1,000,000 and over $800,000 has been lost in other operations.

A small Austrian Westinghouse company, organized in 1906, has a factory for the manufacture of tungsten lamps near Vienna, and has so far made a fair financial success.

The Canadian Westinghouse Co., in contrast to the European companies, has been uniformly and increasingly successful. It has paid dividends regularly since 1903 at the rate of 6% per annum, with an extra 1% in 1910.

It seems to us that this experience of the Westinghouse company in connection with its foreign investments, is of great importance and interest. It illustrates the extreme difficulty which any concern finds in establishing profitable branches in foreign countries.

One of the prime difficulties in connection with the profitable operation of the great industrial plants of the present day is the difficulty of securing efficient management. If this is difficult at home, where the directors and officers have the advantage of wide personal acquaintance, how much more difficult is the task when it is attempted to establish a plant in a foreign country and secure for it an efficient organization?

Very few American engineers or business men, no matter how successful they are on this side of the water, are competent to go into a foreign country and establish there a business similar to what they have made successful here. The differences in business methods, in business customs, the barrier of difference in language, the limited personal acquaintance, the radically different social and economic and political conditions—all these constitute an enormous handicap on the American concern which attempts to set up a profitable business on foreign shores.

Apparently the Westinghouse company was in as advantageous a position to establish profitable houses abroad as any company could possibly hope to be. It possessed important patents and much manufacturing and engineering information developed by experience in this country, and unquestionably of great value. It had, in addition, the advantage of great prestige. Mr. George Westinghouse, long the head of the company, is rightly recognized the world over as one of the greatest inventors and engineers of this or any other nation. The advantage of this reputation and prestige in financing the construction of foreign works and in obtaining advantageous contracts to keep them busy was a very great help to success.

Nevertheless, with all these great advantages, it appears that all these European ventures have been financial failures and the company would be many million dollars better off to-day had it never invested a dollar on the other side of the Atlantic.

It is greatly to be regretted that this should have been the result, for the technical excellence of the work for which Mr. Westinghouse has been responsible, and the large amount of pioneer work which has been carried out by his companies at home and abroad, have been of world-wide importance in advancing both electrical and mechanical engineering. That equal success should not have been reaped financially will be regretted by American engineers everywhere; but the object-lesson of this experience is one which they will study with profit.

The old scheme for a ship canal from Lake Erie to the Ohio River has been revived, and a law has been passed in Ohio authorizing the counties through which the canal will pass to vote bonds to provide the money for its construction. It is rather an interesting commentary upon this legislation that Governor Harmon, of Ohio, did not sign the bill, but permitted it to become a law without his signature. It is a fair inference, perhaps, that he did not approve of the measure and yet deemed that in its present form it was so innocuous that it was not worth while to veto it.

Why the counties along the route of this proposed canal should burden themselves with debt to aid in its construction is not apparent to the ordinary observer. Even if the canal should carry the amount of traffic its promoters hope for, the inhabitants in the adjacent counties would derive no substantial income to help them pay for the canal by sitting on the banks and watching the boats go by.

As projected, some 14 years ago, the canal was to be of moderate draft, only 15 ft.—altogether inadequate to provide for the modern lake freight vessel. The canal, therefore, cannot save the transfer charge on ore or coal at the Lake port. Its sole economy would lie in its possible saving over the cost of the rail haul between the Pittsburg District and the Lakes. Even if there should be a slight saving under this head, it would probably be offset by the greater terminal charge on the ore delivered in boats than in hopper-bottom cars.

Doubtless, the promoters of this waterway, like most other waterway promoters, would like to plan, regardless of expense, and build a waterway between the Ohio and Lake Erie big enough to float the largest lake vessels. Nature, however, unkindly stands in the way by providing only a limited supply of water available for the summit level of such a canal.

Taking all things into consideration, it would appear that the proposed canal is not much nearer reality, by reason of the action of the Ohio Legislature. The latter body can be forgiven, however, since, by all accounts, it has done much worse things.

Not in a very long time can one recall a rainfall which produced greater benefits over a wider extent of country than the showers which have fallen in the territory east of the Allegheny Mountains since the end of May. The rains came at a time when the crops all over New England and the Middle States were in extremities for moisture; and the amount of water falling has been sufficient in most sections, fortunately, to well saturate the soil.

Welcome though the rains have been to the farmer, they have not been sufficient to aid materially the municipal water-supply situation. Their chief benefit has been in raising the ground water level, and refilling the depleted underground reserves from which the springs and brooks are fed. The soil was dried so deeply by the long drought in April and May that in most sections the rain which has fallen in June has added very little to the stream flow. Since June 1 the average rainfall over the Croton watershed has amounted to 3.05 ins., according to the official measurements made at various stations on the watershed by the New York Department of Water Supply.

Of course when one is in an extremity very little help is very welcome; and every inch of rain in the Croton watershed this summer is a blessing to New York City. As Mr. Veiller well showed in these columns two weeks ago, however, a rainfall sufficient in amount to fully relieve New York from danger of water shortage is rather to be counted among the possibilities than among the probabilities.

Some Engineering and Economic Results of the Commercial Motor Vehicle.

Some fifteen years ago, when the automobile was in its early stages of development, Engineering News ventured the prophecy that the great future business for the automobile manufacturers lay in the development of the commercial vehicle rather than the pleasure vehicle.

At the time that prophecy was made, no one of any conservative disposition could possibly have imagined the enormous magnitude of the pleasure automobile business that was to grow up in the years following. This business has been so large and so profitable that manufacturers have only recently given attention to the business in commercial motor vehicles.

It may have seemed during these past years that our prophecy of long ago was wide of the mark. At the present time, however, there is much to indicate that that prophecy will at no distant day be fulfilled.

If one studies the reasons why the motor vehicle for pleasure has come into use by thousands and hundreds of thousands, while the motor vehicle for business purposes is still exceptional, he finds the main reason to be the financial one. People have bought automobiles for pleasure use, not because they cost less to buy or to run than horses and carriages, but because they got more fun from the motor car and could do things with it that were not at all possible with the older method of travel.

But when we turn from the pleasure vehicle to the commercial vehicle we find that the dollars and cents argument is the controlling one. The commercial motor vehicle must be able to show an all around saving in the cost of doing a given task before it can expect to find favor as compared with the horse-drawn vehicle. Many early attempts to introduce various types of motor trucks resulted in failure because the vehicles could not pass this test.

Further, the motor-vehicle must make a very substantial saving over the simple, cheap horse-drawn vehicle in order to win success. Any motor-vehicle equipment is going to require a large investment compared with horses and wagons, and the purchaser must be shown a good profit on this investment after the items of depreciation and repairs are provided for.

The average merchant, or manufacturer or contractor is not going to make a large investment in motor trucks or motor delivery wagons unless these vehicles can earn a good deal more than 6% net on their first cost. Most concerns are borrowing money at that rate to use in their business.

At the present time, however, experience accumulated from many sources appears to show that there are commercial motor vehicles now on the market which can, under favorable circumstances, show a large saving over the cost of working with horse drawn vehicles.

The great advantage of the motor vehicle is that it can run at higher speed and carry heavier loads than any vehicle drawn by horses. Every engineer who has made an analytical study of the cost of wagon traffic knows that one of the largest items in the ton mile cost of freight haulage over common roads is the wages of the driver. It is an interesting fact that the lowest ton-mile costs for haulage by wagon over common roads in the United States are not made over the improved roads of the East. They are made in remote districts of the West, still beyond the reach of railways, where goods have to be hauled long distances over the crudest sort of highways

and where the volume of traffic is such that teams of eight or a dozen or more mules are used to a load and one driver manages a load of several tons.

It will be apparent from this that one of the most hopeful fields for the use of motor trucks is in any industry where the volume of traffic permits heavy loading and long hauls. The motor vehicle will make a better economic showing in heavy trucking, for example, than in light delivery wagon service. In the latter service, again, the advantage will be much greater if run on a suburban and country route, where distances are long and stops are few, than on a city route, where a small area is covered.

In an article published elsewhere in this issue, we have reviewed some of the recent applications of the motor vehicle to heavy haulage, and an interesting showing is made of the extent to which the commercial motor vehicle of large size and large capacity is already in use.

Another illustration of the extent to which the commercial motor vehicle has become a reality is furnished by the special exhibitions held last fall, both in New York and Chicago, showing the most recent work of commercial vehicle manufacturers. We understand that a number of prominent concerns in this field already find their manufacturing capacity taxed to fill their orders.

It should not be understood, however, that the commercial motor vehicle has already attained mechanical perfection. On the contrary, a critical study of the machines exhibited in New York last fall indicated the great opportunities for further achievement by engineer inventors, intelligent designing engineers and enterprising manufacturers. A large proportion of the motor trucks now on the market have been constructed by the simple process of putting the engine of an ordinary pleasure automobile upon a truck body. There are, of course, advantages from the manufacturing point of view in this plan. It is a very easy and simple way to get into the motor truck business. We believe, however, that the future successful motor truck is likely to be built on very different lines from most of the machines at present in use. The engine for a commercial motor vehicle ought to be a much simpler machine and one much cheaper to build and to maintain than the engine which is demanded by the fastidious purchasers of passenger automobiles. For example, instead of four-cylinder and six cylinder engines with their multiplicity of parts it should be possible to make a two-cylinder engine, which would be sufficiently well balanced for use on a heavy truck, which has a substantial frame to take jar and vibration.

There seems also a need for some more flexible form of gear-changing device on heavy trucks than the sliding gear which has come into general use on passenger automobiles. To change the relative speed relations of a truck carrying a load of two or three, or even seven or eight tons, and the high power engine which drives it, by means of sliding spur gears is too brutal treatment to be applied to even the toughest alloy steel, with hopes of permanent success.

There is room also for originality and high-class design in connection with wheels and tires. The rubber tire properly belongs on a passenger vehicle. A machine which has to earn its living has no business using such expensive material. At present tire costs are one of the largest items in the operating expenses of all classes of automobiles. The builders of farm tractors, where costs must be kept at the bottom in order to do any business, abandoned rubber tires at the start. The necessity for the use of steel tires with commercial vehicles becomes more evident with the increasing size and carrying capacity of the vehicle. If sufficient traction is not secured by driving the rear wheels alone, it will be necessary to adopt some of the plans for propelling all four wheels of the vehicle. The saving over the cost of rubber tires will pay for the more complicated machinery necessary to effect this.

Another change likely to be made in the commercial automobile of the future, particularly the machine of large capacity, is the use of some cheaper fuel than gasoline. Enormous quantities of cheap kerosene are now available, which can be purchased in large amounts for a third to a quarter the cost of gasoline. This kerosene, while not equal in quality to that used for household purposes, can all be vaporized with comparatively simple apparatus, and will with little doubt be made available as a fuel for motor vehicles.

Much more might be said concerning the possibilities in improving the commercial automobile, but we suggest these few points merely to indicate that the future success of the machine is certain, since improvements which will largely reduce its cost and increase its reliability may be expected in the future. If we can safely assume that continued supplies of liquid fuel will be available in coming years at no considerable increase in cost, then the eventual supplanting of the horse by the motor on all classes of commercial vehicles may be taken as practically certain.

There will result from this change many developments of great importance to engineers. It seems worth while to point out a few of them. One of the most interesting is the substitution of motor vehicles for horses in fire stations, especially those in the smaller cities and towns where a large populated area must be protected from a single station. Every one realizes the importance of prompt service in connection with fire alarms. The automobile enables the time required to get from a fire station to the location from which an alarm has been sounded to be reduced to a third of what is necessary with horses. In a hilly country or where any large territory is to be covered, an even greater reduction may be made.

Further than this, an automobile fire engine, hose-wagon or hook-and-ladder truck costs nothing whatever to maintain when it is not in use. The actual mileage covered in a year is trifling, and the economy compared with the maintenance of horses in fire stations is enormous. A smaller number of fire stations may be made to afford better protection to the same area than is possible where horses are used. The labor required to care for horses and the number of men necessary to harness them and start them from the station in quick time are also items which are eliminated by the automobile.

The automobile also opens new possibilities for the use of the chemical fire extinguisher. A country village which at present has no fire apparatus whatever, by purchasing a comparatively simple and light automobile equipped with chemical extinguishers, and locating the machine where some man who knows how to handle it is engaged always at a regular occupation close by, can be assured of very satisfactory fire protection at nominal cost. The building of motor vehicle fire apparatus to supply the cities and towns of the United States represents by itself a business large enough to keep a considerable number of automobile factories busy during the next dozen years.

The automobile has great possibilities as a machine for reducing terminal costs of freight handling. Every one knows the difficulty of handling a horse-drawn truck in cramped quarters. A great deal of expense is incurred by every merchant and manufacturer in conveying materials and finished goods to and from the point in his store or works where they can be loaded to or unloaded from the horse-drawn trucks which travel to and from the railway station. The automobile can eliminate some of this useless handling. The future store or factory will be so designed that automobile trucks can run directly into the packing or shipping room or erecting shop for example. Perhaps future railway freight-receiving and delivering stations will have arrangements so that motor trucks can be run alongside of freight cars. Where this can be done, it will make even larger savings possible than those due to the ability of the motor truck to haul heavier loads at higher speeds than its older rival.

Another use for the motor truck to which it would be difficult to place a limit is in direct haulage over considerable distances to save an intermediate railway journey. Direct deliveries may be made by automobile from a city wholesaler to his customers in towns 20 or 30, or even 40, miles away at less cost, perhaps, than would be involved in the hauling to the railway station and hauling from station to receiver at the other end of the route, when the various rehandlings that are made necessary by the railway shipment are taken into account. The saving in cost of packing alone, where this method of delivery is used, may often make its adoption worth while.

There are large possibilities also in the use of motor-propelled vehicles in industrial plants, shops and warehouses in place of the industrial railway or the overhead carrier, both of which systems are in extensive use. With present-day shop floors of concrete or wood-block paving, motor trucks can be run over them with little more friction than over the rails of shop tracks. A great advantage over the rail system is that the trucks can be run anywhere. There is no stoppage for turntables or switches, or because of cars blocking the line ahead, as happens so often with industrial railways. In such a system, where current for charging is available at low cost and where the loads to be hauled are light, storage battery trucks appear to have great promise. The extent of this one field alone is so great that it will tax the ability and enterprise of many engineers and many manufacturers to adequately cover it.

The experience already accumulated with the motor vehicle has abundantly demonstrated that one necessary feature to its successful use is good roads. There are few existing types of motor vehicles capable of carrying large loads which can compete as yet with the 10 or 20-mule team on the Western plains. That there are possibilities in this direction will certainly be admitted, and some manufacturers are already working in this direction; witness the "Caterpillar" traction engine recently illustrated in these columns and the farm tractor of the Avery Co. shown in this issue.

For the most part, however, it must be said that the motor vehicle is at present confined to good roads. When it strikes a soft spot or a slippery spot, it has an uncomfortable habit of digging a hole and burying itself with a promptness that would make any ground-burrowing animal known to zoology ashamed of its feeble efforts.

An excellent exemplification of the dependence of motor trucks upon good roads is furnished by the experience of an enterprising truck manufacturer who last fall sent a 5-ton truck to make a journey from Denver to Los Angeles, loaded with 3½ tons of lumber.

It took 68 days to make the journey of 1,519 miles from Denver to Los Angeles, an average distance of about 22 miles per day. The man who ran the truck over this journey is quoted as follows:

> Not for $10,000 would I repeat that awfully nerve-racking, back-breaking punishment again. The pictures which we made of the hardships we went through tell the story graphically and I can assure you that these pictures do not represent exceptional conditions but average everyday conditions; not hardships for a few minutes of a day but in many instances for the whole day and day after day.
>
> Not once in the entire 68 days of the grilling punishment did we have even moderately easy going. We were constantly digging the big truck out of the bottomless mires which only the axles prevented sinking further or planking the road continually with lumber from our cargo to secure traction sufficiently to creep along at a snail's pace. Where there were even the crudest apologies for roads, the wide tread of the big machine prevented the rear wheels from tracking in the narrow road, with the result that for many days the tires of the back wheels ploughed a deep furrow on both sides which sometimes had a depth equal to the vertical distance from the hubs to the tires.

The journey was made, we presume, to demonstrate the ability of the truck to pass unscathed over the roughest and most unpromising territory. What the demonstration really showed, however, was that if the truck or any other vehicle of similar construction, is to be operated at a profit, it must have reasonably decent roads to run on. Judging by the official accounts of the trip which were given out, the load of lumber was pretty well worn out during the journey through its frequent use ahead of the truck to carry it across soft spots in the road.

Such freight hauling by motor vehicle may be

good advertising, but it is not good business. In fact it is extremely doubtful whether any vehicle weighing as much as four or five tons with its load can be profitably run over soft dirt roads.

The advent of the commercial motor vehicle is interesting to highway engineers from two points of view. In the first place it will enormously increase the demand for good road construction. In the second place it will likewise enormously increase the wear and tear upon road surfaces. Perhaps this is the most important engineering problem of all those presented by the advent of the motor vehicle.

As every engineer engaged in highway construction knows, the advent of the pleasure automobile has revolutionized our whole problem of highway construction, has practically doubled the cost per mile of permanent macadam roads and has probably much more than doubled the annual cost of maintenance. It has been hoped by the engineers who have most to do with road problems that a fairly satisfactory solution has been reached through the use of the latest and best forms of bituminous macadam, involving an increased expense in construction and maintenance about as outlined above.

If, however, as seems not only probable but certain, we are in the near future to add to our present heavy passenger automobile traffic the traffic of heavy motor trucks, carrying loads of two to eight tons and propelled at speeds reaching 20 miles an hour or higher, what sort of road surface can the engineer provide that will stand the wear, and yet not exceed the taxpayers' limit of elasticity? We shall not attempt to answer this question. We doubt whether any one is wise enough to answer it now; but it is one that will have to be answered in the near future.

Sooner or later, the heavily-burdened tax-payer is certain to raise a protest at the enormous burden imposed upon him for road maintenance. Sooner or later, conservative sentiment will awaken to the foolishness and wickedness of unloading upon posterity the burden of paying for good roads which are destined to be worn out long before posterity arrives. Sooner or later, we must place upon the owner of the automobile the burden of paying for the wear and tear which his machine produces upon the roads.

In Great Britain the Lloyd-George budget of 1909 laid special taxes on motor vehicles in proportion to their power, the proceeds of which are used for road improvement, "The Engineer" (London), recently declared that "the old water-bound macadam road is doomed" and continued:

> There are something like 27,000 miles of main roads in England and Wales alone, and most of them require to be re-made. It is estimated that the cost of providing a proper foundation for these would be something approaching £55,000,000 ($275,000,000). These figures, together with the fact that there are nearly 220,000 motor vehicles licensed and registered for use in the United Kingdom, show how immense the task of the Road Board is.

In the United States, our greater use of pleasure automobiles on the one hand and the severe weather conditions of winter frost and summer drought make our road problems far more difficult than those of European engineers.

The fool propaganda of good road enthusiasts has widely disseminated the notion that good roads are cheap to build and once built cost little to maintain; and this notion has caused a vast amount of trouble for engineers.

It is important that the public should understand that good roads cost money and a lot of money to build and to maintain, and that with the advent of the commercial automobile their cost per mile for both construction and maintenance is likely to be materially greater in the future.

LETTERS TO THE EDITOR.

Efficient Business Organization and the New York State Government.

Sir: The writer desires to express his unqualified approval of the sentiments set forth in the editorial headed "Efficient Business Organization and the New York State Government" in Engineering News of June 15.

The expression of such sentiments by a non-partisan journal of high standing cannot fail of good result. It is the wish of the writer that the engineering profession may be placed on record in such matters by many articles of similar import.

Very truly yours,
Francis Henry Wisewell.

22 Broad St., Utica, N. Y., June 15, 1911.

More Concerning Prof. Taylor's Critique of Higher Education.

Sir: I note with regret the spirit in which Professor Ricketts of the Rensselaer discusses my paper which was published in your issue of May 11 and which contained some criticism of the conduct of our higher educational work in colleges and universities of the country.

For the first time in my life I here see in his discussion my name coupled uncomfortably close, over the signature of a reputable scholar and engineer and in a reputable journal, to such words as "Fool" and "False general statements." I should have thought that the general spirit of my article, which was conceived in no unkindness toward any individual or school as well as the general tenor of my past life, which has not been spent under a bushel, would have warranted me in expecting at the learned professor's hands a more patient, a more respectful, and a more dignified discussion.

Although Professor Ricketts' action in this case is strangely like that of a man whose toes have been trodden upon, I shall endeavor not to reply in a similar vein. If, however, Professor Ricketts is right in asserting, as he virtually does, that there are no students or teachers at Troy of the kind described in my paper, not only is he to be congratulated, but it seems that he should be grateful that circumstances have arisen under which he can say so with such telling effect.

He seems to have overlooked a part of the paragraph in my paper in which I said that I knew that the kind of teacher and student described were not typical of the men in our institutions, though he ridiculed the latter part of that paragraph. I wished, however, to show that the type did exist in more or less unpleasant quantities. I made no sweeping general charges for I knew that there were institutions to which not a single criticism I made would apply, the Louisiana State University at Baton Rouge, for example.

The information that Professor Ricketts conveys in regard to the University of Wisconsin is just a bit gratuitous. I was on the faculty of that institution for four and a half years and did not leave because I had to. Many of its professors are among the strongest personal friends I have. Two of my children have graduated there and I have others that I hope will do so. I think the University has one of the strongest and wisest Presidents in the country—if not the strongest and wisest—and taking the institution as a whole, by and large, and considering what it has done and is doing for its state, I think it is the foremost university in the United States.

But in round numbers the university has 4,000 students and 400 teachers, quite a municipality in itself. If in our municipal life we see anyone, citizen, alderman, or mayor abusing his privileges, we do not consider that we are disloyal to our home town if we raise an outcry against him; quite the contrary. Why not so in the university?

Where the university and the college are concerned, Professor Ricketts and his ilk require that we outsiders applaud or keep quiet. We must keep quiet if a professor has been kept in his chair for 25 years or so—until a former student who knows how inefficient the professor is becomes a trustee of the institution—and then he is turned out as an incompetent. We must not intimate that any wrong has been done the students in this department for a quarter of a century.

If the students under one of the highest paid professors fall asleep in his lecture room while their professor spends and has spent for years 75% of his waking hours engineering real estate deals, we musn't say a word. Let us rather remember how great is our university!

"U Rah Rah Wisconsin.
Praise to thee we sing"—et cetera.

The varsity toast is already arranged to tell us what to do.

It strikes me, too, that possibly Professor Ricketts may be the victim of some self-complacency in assuming, as he does at the last, that he with his criticisms has bloodied my nose as a reward for my temerity in sticking my face into the tent where he and the other elect are arranging the great educational show of the country as they see proper.

For some of Professor Ricketts' compeers are not in accord with him. It would be embarrassing for most teachers to come out and endorse this paper, but I have a number of personal letters which do so. A president of a college larger than Rensselaer and fully as important, writes, "I agree with you heartily in all of your points." One of the deans of a large western school writes endorsing the paper throughout and adds that he has sent for a number of extra copies of the paper to distribute among his governing board. One of the very foremost professors of English in the country writes me "There is no doubt, I think, that your criticism is well taken—I found your article thoughtful and suggestive."

I trust that Professor Ricketts' discussion will lead many to read the original paper who have overlooked it before, and I am entirely willing that the paper and its criticism should pass in review, as they stand, before the educational public.

W. D. Ta...
7810 Bond Ave., Chicago, Ill., June 6, 1911.

An Apparatus for Applying Chemicals to Water.

Sir: You published an article in Engineering News of May 25, 1911, p. 619, in which you described an apparatus for applying chemicals to water flowing in a pressure main. You state: "Thus the effective pressure difference forcing the solution through the feed pipe is always proportional to the existing rate of flow through the main." And again, referring to the pressure drop through the valve F, you state: "which varies in direct proportion to the volume of water passing through."

Now, neglecting friction, the drop in pressure is the difference in velocity heads. Since the quantity flowing is in direct proportion to the velocity, it follows that the drop in pressure is directly proportional to the square of the quantity and not to the quantity itself, as you have stated.

It seems to me that the reason why the apparatus will inject a quantity of solution in direct proportion to the amount of flow in the pipe is because the quantity forced through the valve F will vary as the square root of the effective head on it and, since the head varies as the square of the quantity in the main, it follows that the amount passing through the valve will be in direct proportion to the quantity in the main.

F. C. Young.

June 3, 1911.

Instructor in Civil Engineering, State University of Iowa, Iowa City.

The Certainty of Water Waste and Its Effect on the Quality of the Water Stored in Reservoirs.

Sir: Apropos of your admirable discussion of the water situation in New York the following facts and suggestions may be pertinent:

An experience of some 17 years with what was at first a superabundant supply—a reservoir with available storage of 135,000,000 gals. and legitimate daily consumption of less than 250,000 gals.—gives strong emphasis to some points in this controversy. We quickly learned the lesson, in the early history of the works, that the quality of the water has a close relation to the level of the surface of the reservoir; that a very considerable surplus is necessary to hold the average depth sufficient for maintaining the quality up to a satisfactory standard—especially in winter when the ice covering of 24 to 36 ins. in thickness makes about 20% of even the full reservoir non-available, and imposes a period of winter stagnation on all of the remainder which cannot be complacently regarded from a sanitary standpoint.

Your high officials in New York who think that metering household supplies may be detrimental to family hygiene, by curtailing use, raise an objection which is more ingenious (if it be ingenuous) than rational. The matter of real consequence in promoting the conservation of storage by checking waste is the undoubted *benefit to the quality of the entire supply.*

As to waste the writer has recently found it necessary to make a public demonstration. Having works on the gravity system, built at the joint expense of Dartmouth College and the Hanover village precinct of Hanover, N. H., with an unlimited and unstinted supply, flat rates were adopted. But, with increasing number of college buildings (including 16 dormitories) and residences, the number of fixtures was multiplied several times and the chances for waste in similar ratio. When the rate of reservoir depletion showed a consumption of nearly half a million gallons daily the directors began to talk of need of more storage. But the writer—as an engineer and president of the company—was convinced that the supply was quite sufficient and that the immediate action needed was to prove the waste. Accordingly meters were procured in three different sizes and applied to typical services as follows: private houses, drug stores (having ice-cream freezers run by water motors), stables, students' boarding clubs, students' society houses, college dormitories and laboratories, and the college "commons" where about 600 students eat. In less than a month the revelations surprised everybody and convinced the skeptics. In one tenement and in a society house the meters recorded about ten times any reasonable demand, with no leaks apparent or suspected. But investigation at once revealed derangement of the ball valves serving attic

tanks and a similar cause explained a waste 15,000 gals. per day at the hotel. A waste of 25,000 gals. per day in "the commons" was detected and found to be due to a neglected flush valve. But further details are needless; it was simply a repetition of the experience of many water-works superintendents. The *certainty* of waste when there is no check on the consumer was demonstrated, as is *always* the case when the test is applied.

As to the relation between meters and personal hygiene: We have found by repeated tests extending over a year, in some cases, that the average family consumption rarely exceeds 35 gals. per person daily and in extreme cases scarcely reaches 50 gals., while it is generally nearer 25. This includes laundry, baths and all household uses excepting lawn sprinkling, and all under the flat rate scale. In college dormitories with no restriction of use in rooms, closets, shower baths, etc., and much probable waste, tests of several buildings housing from 45 to 90 students each, showed an average daily consumption of about 50 gals. per capita. Dormitory tests made eight years ago yielded practically the same result. If we assume a family of six persons using 150 gals. per day a common meter rate would reduce to about 3 cts. per day for the family, which would be considerably less than the ordinary flat-rate charge where the usual sanitary fixtures are in use; that is about $11 per year as against $16 to $18. But some towns charge lower meter rates than 20 cts. per 1,000 gals., on which the above result is based. However that may be, our consumers, who are especially well informed on matters of personal hygiene, would generally have smaller bills by meter rate than they are now paying by the system of charges for the fixtures used, assuming no waste in either case.

In conclusion, supposing that closets and bath-tubs are essential sanitary conditions for the family economy, we have proved that meter rates do not curtail the legitimate use of water, while they do reduce the cost to the consumer.

Robert Fletcher, Mem. Am. Soc. C. E.
Director of Thayer School of Civil Eng.
Pres. Hanover, N. H., Water Works Co.

Nyack, N. Y., June 12, 1911.

The Introduction of Water Meters in New York City.

Sir: It is hard to understand how any one, after reading the article advocating the introduction of water meters in New York City, in your issue of June 8, can believe that the use of meters is not absolutely necessary sooner or later, in order to reduce the large wastage of water which is undoubtedly constantly going on. There are organizations of property owners, however, who are selfishly opposing the introduction of meters. Past experience has proved that with our form of government it is essential for public-spirited citizens to organize in order to keep before the public questions of vital moment, such as this question of the city's water-supply, and in order to secure intelligent and effective action from the public authorities.

I would suggest, therefore, that you address an appeal to the Merchants' Association and to the Chamber of Commerce, who have heretofore taken some interest in the problem of the city's water-supply, in the hope that they may take some action on this question.

Yours very truly,
Howard W. Starr.

30 Church St., New York City, June 12, 1911.

[By way of comment on this letter we print the latest effulgence of Mayor Gaynor on water meters, in the shape of a letter written to the Secretary of the High Bridge Taxpayers' Alliance:

Office of the Mayor.
June 13, 1911.

Dear Mr. Harding: Your favor of June 12 is at hand. I entirely agree with you in regard to putting water meters in dwellings. I do not believe in charging for water according to meter for domestic purposes, or for use in dwellings or tenements. I examined the matter very carefully over a year ago and came to that conclusion, and I see no reason to depart from it.

If heads of houses had to pay for water according to meter, they would be uneasy when their wives and children took baths, for such is human nature. The result would be discomfort and uncleanliness. Every one would hesitate to take a bath sooner than add to the household expense. This would be particularly so among the poor and people of moderate means.

I believe in getting an inexhaustible source of water supply and letting every one use all the water he or she wants for washing and bathing and domestic purposes. That is necessary to keep the community clean and in a good sanitary condition. Tell your association to stick to this. Sincerely yours,

W. J. Gaynor, Mayor.

[Did it ever occur to Mayor Gaynor that where a great city like New York is concerned, there is no such thing as an "inexhaustible source of water supply"? Chicago has the whole of Lake Michigan to draw on for a water supply, but during the recent heated term in Chicago there were large sections of the city where the people complained of inability to secure any water from their house faucets during certain hours of the day.

Mayor Gaynor made an excellent beginning by bringing into the water department at the outset of his administration, the man who had made a national reputation among water supply engineers by putting the water-works of Cleveland on a business basis by the universal installation of water meters. But Mayor Gaynor failed to stand by his appointee and now sets up his own opinion against that of experts in this field. He "examined the matter very carefully a year ago and does not believe in charging for water according to meter," because "everyone would hesitate to take a bath."

This sounds like the nonsensical deliverances with which the Philadelphia politicians used to regale the public in the years when they were trying to wreck the city's water supply system financially in order to gain public consent to the scheme to turn it over to a private corporation. We expected better things of Mayor Gaynor.

That his ill-considered utterance is attracting attention and arousing criticism beyond the borders of New York City is evidenced by a letter which we have received from one of the foremost water supply engineers of the country, whose experience in connection with water-works engineering would be recognized even by Mayor Gaynor. He writes:

I am extremely sorry to see the Mayor of New York preaching such heresy. Providence, R. I., is a fully metered city and there are many others. I have never heard it seriously stated in any city where universal metering was the rule and a wise schedule of minimum rates prevailed, that there was any ground whatever for such evils as the Mayor here conjures up out of his imagination.

Notes and Queries.

Erratum. The grain elevator at Highland, Ill., mentioned in the article on the Unit Construction Co.'s system of concrete construction on p. 727 of our issue of June 15, is of 50,000 bushels capacity, instead of 15,000 bushels.

WHY STEEL IS IMPORTED (?).—Writing on "Durability Tests" in the "Zeitschrift des Oesterreichischen Ingenieur und Architekten Vereines," of June 2, 1911, H. Pudor gives an ingeniously-reasoned statement about the Singer Building in New York City, as follows:

The core of the question of durability is the matter of good workmanship. The architect of the Singer Building in New York bought the steel framing of the building in Germany, not because they have not as good steel in America, but because the workmanship there is not as reliable.

The boom times preceding the 1907 panic have much to answer for, but that they should have led to the above paragraph is really unexpected.

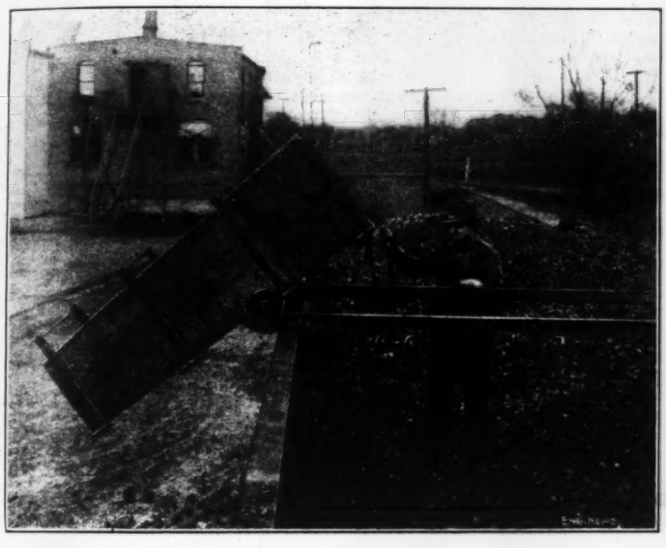

FIG. 1. UNLOADING CHUTE IN PLACE ON A GONDOLA CAR.

FIG. 2. DUMPING CHUTE IN A PARTLY EMPTIED GONDOLA: CHUTE BEING RAISED TO DUMPING POSITION.

A Dumping Chute for Unloading Coal and Broken Stone.*

The device shown in the accompanying figures has recently been put on the market to facilite the unloading of coal, broken stone and similar materials from open cars. It consists of a small chute or car which runs on a rail frame placed across the sides of the gondola car or with one end on the top rail. The coal or stone is shoveled into the chute which, when full, is drawn over or up to the dumping edge of the gondola, with an attached winch. The contents can be discharged into a waiting wagon without waste, the spilling angle being controlled at the dumping winch.

The advantages of such a device in saving of time and labor are seen to be in (1) removing the necessity of keeping a wagon waiting during the time between the first and last shovelfuls of a load, and (2) reducing the labor and waste in shoveling over the edge of the gondola into a wagon. This unloading device is light enough, so that it can be raised into place, or shifted from one car to another, by two men. It is easily taken apart for shipment. The manufacturer is the Stephens-Adamson Mfg. Co., of Aurora, Ill.

*Arranged from information supplied by the Stephens-Adamson Mfg. Co., Aurora, Ill.

Annual Convention of the American Railway Master Mechanics' Association.

The 44th annual convention of the American Railway Master Mechanics' Association was held at Atlantic City, N. J., June 14-16, in connection with the Master Car Builders' Association's convention, held June 19-21, and the annually growing mechanical machinery and appliance exhibition which has for years accompanied these two conventions. This is the sixth consecutive year that the conventions have been held at this location, which is so admirably suited for such a gathering, demanding extensive hotel accommodations, a cool meeting place and a large exhibition area.

The attendance on the meetings of the Master Mechanics' Association was about normal, that is there were probably 300 men present at each of the three four-hour sessions, but it seemed that there was a somewhat wider discussion of the various topics and that contrary to the usual custom at this and similar conventions, the floor was not taken exclusively by a few men, competent and willing to discuss the subjects in hand, but that more of the younger and less-widely known members were in evidence.

The secretary's and treasurer's reports showed that the association was in a prosperous condition. The consolidation of the American Railway Master Mechanics' Association with the Master Car Builders' Association into one railway mechanical association, so actively urged these past two years, was noted only by a Committee appointed last year which reported that the best advice was that such a consolidation would be strictly legal, thus overcoming some doubts that were expressed last year.

Besides the President's address there were 19 Committee reports presented in more or less detail and one individual paper read and discussed.

President's Address.

The President (C. E. Fuller, Union Pacific R. R.) called attention to the numerous state and federal laws which had been enacted during the year past and recommended two things in regard to them, (1) that there be an effort made to harmonize the state and federal laws to a greater degree than now exists and (2) that the railways straightway set about carrying out the spirit and the letter of these laws so as to show to the various railway commissions a willingness to do all that is required. Further, Mr. Fuller recommended a closer observance by the railways of the rules and practices recommended by the Association, so that that unity in which there is strength might be more apparent in the mechanical departments of our railways. He deprecated the present popular clamor for "efficiency" in railway operations, saying that such efficiency has always been the watchword of the mechanical departments and that none of the present-day nostrums would add to it. In detailed recommendations he suggested the advisability of the Association taking up the apprentice question through a proper committee, and the establishment of a technical bureau in the Association for the purposes of study and advice to members. Finally, he advocated the early consolidation of the Master Mechanics' and the Master Car Builders' Associations.

Individual Paper.

SUPERHEATER LOCOMOTIVES.—For two years past Prof. W. F. M. Goss and his successor at Purdue University, Prof. C. H. Benjamin, with Prof. L. E. Endsley have presented papers at this convention on tests of locomotives equipped with superheaters. These tests have seemed to show a progressive improvement in the efficiency of the locomotive with an increase of superheat. It was also apparent that this improvement in the efficiency had not reached a maximum under the degree of superheat then used—about 200°. The tests this year were undertaken by Profs. Benjamin and Endsley to investigate the effect of a higher degree of superheat, say, from 200° to 275°, upon this improvement and also to find out, if possible, whether there would be any difficulty with the lubrication of the slide valve under these high conditions of superheat, as was predicted on the floor of the convention last year.

The same locomotive was used in the present tests as in the ones previously reported except that instead of a Cole superheater being used, with heating surfaces varied from 109 to 193 sq. ft., a Schmitt superheater was installed, with a heating surface of 324 sq. ft. Following the method primarily adopted, the tests on the Schmitt superheater were run at 200, 160 and 120 lbs. pressure and with degrees of superheat running between 200° and 240°. It was found that the needed lubrication of the slide valves was no greater under this high superheat than under the lower degree used in the other tests. It was also found that in steam consumption, water consumption and coal consumption the Schmitt test, with the high degree of superheat is lower than either saturated steam or any of the other lower degrees of superheat as developed by the Cole superheater in the previous tests. These investigations, taken as a whole, show that the lower degrees of superheating save so little in fuel consumption as to make their use hardly worth while. In conclusion the authors state:

A locomotive equipped with a superheater giving from 200° to 240° of superheat will, during the time of running, effect a saving in coal consumption of from 20 to 30% over that of the same locomotive using saturated steam.

It would seem that the total gain in efficiency which could be obtained from superheat in a locomotive would not be reached until the temperature became too high for practical purposes.

Prof. Arthur Wood (Pennsylvania State College) called attention to the fact that the economy data of the tests were based entirely on the coal consumption per indicated horse-power and did not take into account the possible extra depreciation of the equipment for a superheated locomotive. Prof. Endsley replied that this was impossible to discover by a test on the one locomotive available at the laboratory, but would have to be left to tests on a number of working locomotives in service.

Committee Reports.

MECHANICAL STOKERS.—The standing committee on mechanical stokers gave some short notes on seven different stokers and reported upon the subject as follows:

The Committee feels fully justified in expressing the opinion that such progress has been made in the development of mechanical stokers to warrant railroads installing a limited number upon large locomotives at least, and thus lend their aid in the perfection of a device which the Committee has concluded is a necessary appliance to heavy tractive-power locomotives, when such locomotives are called upon to exert their full capacity for a prolonged period.

The large locomotives at present being constructed would unquestionably render service nearer their maximum capacity if the firing were mechanical, and the Committee is of the opinion that it behooves the members of this Association to participate actively by utilizing such stokers as have been developed, and, by actual application, assist in the solving of the many problems which must naturally present themselves during practical operation.

The benefits to be derived might properly be again referred to viz.:

Utilization of the maximum boiler capacity of locomotives;
Reduction of black smoke, because of the possibility of maintaining a thin, level fire;
Application of coal in more minute quantities;
Improved life of flues and fire boxes;
The reduced labor required should make the positions of firemen more attractive, which will carry therewith obvious benefits to the railroads.

The requirements for mechanical stokers, as recommended by your committee, in brief, are:

They should be capable of firing coal in excess of the maximum requirements of the locomotive;
The fire-box door should be free of any attachment which would prevent the fireman from giving such attention as fires may require;
They should be entirely mechanical from tender to grate;
They should be capable of handling bituminous run-of-mine coal, which will include a coal crusher, mechanically operated, on the tender;
They should distribute the coal in the fire-box in such a manner as to call for no assistance from the fireman other than regulation of supply and possibly the adjustment of the mechanical appliances for distribution;
They should maintain an ideal fire for economic coal consumption without emission of black smoke in objectionable quantities;
They should be reliable in service.

This report does not include any tests comparing efficiency of mechanical stokers to hand firing, as the Committee believes that mechanical stokers must be made flexible and reliable machines before any prospect of improved economy in fuel consumption may be expected.

Tests comparing inferior fuel used with mechanical stokers to regular supply for hand firing, thus taking advantage of difference in present fuel values, should not be accepted as proof of economy, as such economy would not maintain with the extension to any considerable number of mechanical stokers.

The progress during the past year has been sufficiently marked to lead the Committee to believe that it can present a final report at the next convention upon at least several of the stokers which have already developed sufficiently to perform actual continuous service.

There was some opposition to that part of the recommendations which demands that a stoker should be entirely mechanical from tender to grate, inasmuch as that requirement excludes most of the stokers now under trial. Some members maintained that the development of a loading device was an easy mechanical problem, which could be readily solved once the firing portion of the stoker was perfected. The members of the committee, however, stuck to their statement. Mr. George L. Fowler (Railway Age Gazette) stated that from his observations of several good stokers under running conditions, it was very easy to keep up steam with them and the amount of smoke produced was measurably lower than by hand firing. The main difficulty was that they seemed to use too much coal, due probably to the efforts of the tending fireman to work as hard as he had been accustomed in hand firing.

Mr. D. F. Crawford (Pennsylvania Lines), the originator of the Crawford stoker, stated that it was the intention to increase the coal consumption, but at the same time to increase the power of the locomotive up to its capacity. He wanted every engine to burn enough coal to develop its power up to the adhesive ratio, and then to increase the loads behind that engine to that limit. This is the true function of the mechanical stoker, quite as much as to reduce cost, smoke and the labor of the fireman.

LOCOMOTIVE WATER TREATMENT.—A committee appointed to consider the best methods of treating corroding water which must be used in locomotives when the density of traffic does not warrant the construction of large water-treating plants, gave three designs of small wayside stations where soda ash or other compound may be mixed with the water. The use of barium hydrate was suggested as a novelty, but this is as yet so expensive as to be almost prohibitive, although the results from it are very good.

LOCOMOTIVE FRAMES.—The Committee on Best Construction of Locomotive Frames found that little improvement in the proportion of breakages of these frames has been noted since the previous report of the Committee in 1904. Nearly every road reports a large number, one road as high as 39% of all engines passing through its shops, and every road reports the failures to increase with the age of the locomotive. Aside from some minor considerations the recommendations of the Committee to remedy this defect is that all frames should be of one piece and be made of good cast steel, thoroughly cross-braced to reduce so far as possible the constant deflections that undoubtedly hasten failure.

SMOKE PREVENTION IN FIRING UP LOCOMOTIVES.—The special committee on this subject presented a report which appears elsewhere in this issue. There was considerable interest in the subject on account of the very stringent laws that are now being passed in many cities requiring all smoke from locomotives to be kept down to a negligible amount. The general expression of opinion seemed to be that this cannot be absolutely secured when firing up an engine, but that the best results are reached by the use of as much wood as possible and by not hurrying the men.

MAIN AND SIDE RODS, PISTON RODS AND CROSS HEADS.—Two committees, one on Main and Side Rods and one on Formulas for Diameter of Piston Rods and Size of Cross Heads for Locomotives, presented reports upon the design of these respective details. Each report is based

on the replies of a number of roads and contains exact mathematical methods of figuring the parts as well as drawings giving proper sizes.

ENGINE HOUSES.—The Committee on Repair Equipment for Engine Houses in its report advocates a greater amount of time and money to be spent on engine or roundhouses, in order that much of the necessary repairs be made there instead of the main shop. Every day that a locomotive must be in the main shop means more than a day's loss of service for that locomotive, and the earnings of the locomotive for that lost time during the year would capitalize to a very fair amount which might economically be spent on the equipment of the engine houses, where the work could be carried on in much less time than at the main shop. Reduced to a summary these conclusions are as follows:

In studying the requirements of engine houses, determining the kind of work to prepare for and the repair equipment needed, the following points should be kept in mind:

Locomotives should be held out of service for repairs as short a time as possible.

Locomotives should be kept as near 100% efficiency as possible.

The effect on earnings of time saved by repairs made at engine-houses.

The effect on engine efficiency of repairs made at engine-houses.

The smaller fixed charges for repairs made at the engine-house compared with those at the main shop.

The effect of storeroom stocks on engine earnings.

Engine-house men should have ideals and methods quite different from those of shop men.

It is important that engine-house conditions and facilities should be attractive and convenient to get and keep good men and increase their efficiency.

These conclusions can be generalized in the statement that locomotive repairs and repair facilities at engine-houses are warranted when they will result in increased earnings either because of more or better engine service obtained from a given number of locomotives.

LUBRICATION OF LOCOMOTIVE CYLINDERS.—After a thorough investigation of the conditions on the various railways of this country, the committee on this subject concluded that the hydrostatic-feed lubricator is the most satisfactory device now in use for lubricating locomotive cylinders, for the following reasons:

(1) Familiarity with care and operation by the different classes of labor whose duties are in connection with its use.

(2) Simplicity of design and substantial in construction; the operating parts being better protected from disarrangement or breakage.

(3) A more accurate regulation of the amount of oil applied to the valves and cylinders under the varying conditions of service performed by the locomotive at different speeds and points of cut-off.

(4) Less complication in construction and attachments, with a corresponding lower expense of maintenance.

Although the experience of the hydrostatic-feed lubricator with superheated locomotives has not been extensive, the experience so far seems to show that it is equally effective there. No definite recommendation should be made until the behavior is fully observed.

TIRE CONTOUR.—This committee, after an investigation of general practice, recommended the use of the M. C. B. 1909 contour for all flanged steel or steel-tired wheels on engine trucks, tender trucks, driving wheels and trailing wheels and included in its report drawings showing the proper contour. There was some objection to this recommendation, mainly on the ground that the contour showed too high a maximum flange depth (1½ ins.) and too excessive a taper (1 in 20). These sizes were thought to be hold-overs from cast-iron practice which could readily be reduced in the steel wheel. It was therefore decided that the committee should be continued to look into these matters.

STEEL TIRES.—This committee had not had sufficient time to prepare a full report, but did present a preliminary report embodying recommendations for the manufacture of steel tires. These recommendations provide for the chemical constituency of the tires, their physical properties and the tests which they should successfully undergo. The most important feature of the test is the drop test, which may be called for by the railway.

FLANGE LUBRICATION.—This committee set out to determine to what extent trouble from flange wear of locomotive tires is experienced, the lubricants and means of applying them which are in use, and the effectiveness of lubrication in overcoming flange wear. It was found that the loss from this cause is most excessive and that great savings have been made by the use of flange lubricators. Tables were given showing the extent of these losses and savings, in both cash value and in total mileage, as reported by several roads. A number of methods of lubricating the flanges were given, both in drawings and by description, though no particular method or device was recommended.

LOCOMOTIVE BOILERS AND SAFETY APPLIANCES.—The two committees on these respective subjects had about the same duty to perform, viz., to prepare standards to be adopted by the various railways to meet the requirements of the recently enacted federal laws regulating the safety appliances on all locomotives and ordering a federal inspection of all locomotive boilers. It is the intention of the railways to make every effort to meet the wishes of the government in this respect, and to that end the standards recommended by the committees are very likely to be adopted by all of the roads of the country. The safety appliance report is concerned entirely with details of design, the location of such hand holds, coupling rods, etc., as will meet the ideas of the government inspectors. The boiler inspection report is devoted chiefly to a consideration of the mechanism of the reports, that is, the outlining of the various blanks to be filled in, their replacement on the engines, method of inspection, etc. Both reports were arrived at after conferences between the committees and representatives of the Interstate Commerce Commission and of the employees.

As noted by the President, there is now some confusion between various state laws and the federal law, and it is hoped that legislation will remove this in the near future.

OTHER COMMITTEES.—Last year, upon the recommendation of the President, a committee known as "The Advisory Technical Committee" was appointed to have the initiative in all public matters that should be brought to the attention of the Association, or in which the Association should take action. This committee has not made any definite advance during the year but reported progress, with an indication that it would have some real work to do in the ensuing year. The report of the Committee on Safety Valves, being too late for consideration by the Executive Committee, was held over for another year. The Committee on Consolidation reported as noted above. The Committee on Revision of Standards made no report. The Committee on Minimum Requirements for Headlights reported that it had collected considerable material on this subject, both as to practice and tests, but that the material was so conflicting that it thought best to hold over the report for another year.

Officers.

The following officers were elected for the ensuing year, the usual rule of promotion being followed: President, H. T. Bentley (Asst. Supt. of Motive Power, Chicago & Northwestern Ry.); 1st Vice-Pres., D. F. Crawford (Gen. Supt. Motive Power, Pennsylvania Lines); 2d Vice-Pres., T. Rumney (Mechanical Supt., Erie R. R.); 3d Vice-Pres., D. R. MacBain (Supt. Motive Power, Lake Shore & Michigan Southern Ry.); Treasurer, Angus Sinclair. The Secretary is Mr. Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

THE CLEVELAND RY., Cleveland, Ohio, on June 1 began operation on a straight 3-ct. fare basis inside the city limits, virtually eliminating the charge of 1 ct. for transfers. This was done in response to an order from the City Council and a notice from the city's street-railway commissioner that the interest fund had reached $700,000. Under the operating ordinance such action had to follow the notice. (See Eng. News, March 10 and April 28, 1910.) The order was obeyed but under protest that "maintenance reserve" and "operating expense" allowances showed "shortages" of $264,000 and $121,000, respectively, making a "total shortage" of $385,000 instead of any surplus. While the 1-ct. charge for transfers is still imposed, a rebate of 1 ct. is secured on use of the transfer ticket.

Smoke-Preventing Devices for Firing Up Locomotives at Terminals.*

On account of the laws and regulations of large cities, relative to the prevention of smoke, the Executive Committee appointed this Committee to collect from the various members such information as might be obtainable with reference to the prevention of smoke during the critical period of time when locomotives are being fired up at terminals. That smoke prevention is extremely difficult at this time is evidenced by the fact that most large cities specifically exempt from violations the smoke emitted from boilers while being fired up.

Although only 33 roads replied to the Committee's circular of inquiry, among these were included many of the largest companies and especially those having terminals located within the large cities where the restrictions are most severe; hence it is believed that this subject has been more thoroughly canvassed than might otherwise appear.

The various reports and the experience of the individual members of the Committee would lead to the following recommendations:

BOILER CONDITIONS BEFORE FIRING UP.—The best results are obtained by filling up locomotive boilers with hot water previous to firing up; the temperatures reported varying from 110° F. to over 200° F., the higher being preferred on account of aiding combustion and lessening the time required to raise steam in the boiler.

Where hot water is not available, the temperature of water in the boiler may be raised by injecting live steam below the water line; but on account of the loss of time, the heating of the water, either before or while the boiler is being filled, is recommended.

INDUCED DRAFT.—Two roads reported the use of large fans, connected with the smoke jacks above the roundhouse roof, as a means for producing draft. One of these roads advises that this device was used and tested for a considerable length of time, but was found unsatisfactory and abandoned. The other road is still experimenting along this plan in connection with a "smoke-washer," and is not yet ready to report upon its results except as to its difficulty in the maintenance of the plant—the metal parts having been eaten out several times during the year's experiments.

All other roads report the use of a roundhouse steam blower and the locomotive blower used exclusively.

METHODS OF FIRING UP.—From the reports it would appear that almost every combination of wood, fuel, oil, shavings, cobs, coke and bituminous coal had been used, with more serious objections to some than others. Several roads reported extensive trials of coke, but its use has been almost entirely abandoned because the ashes and gases emitted from the smoke jacks are much more objectionable than smoke when roundhouses are located near viaducts or high buildings; furthermore, it is almost impossible for employees to work in the roundhouse when engines have to be moved from under the smoke jacks to do necessary work, and also the cost of coke is greatly in excess of other fuels in most sections of this country.

While the smoke from wood varies considerably in accordance with the size, quality and amount used, still it is more generally employed for kindling fires than any other fuel where the greatest effort is being made to prevent smoke at such times.

The plan of raising steam to nearly working pressure by means of wood or coke alone has been tried by many roads, but abandoned when it was found that the same results could be obtained by adding bituminous coal carefully to wood fire after the temperature in the fire-box had been somewhat raised.

In general the conclusion is, that although there are many devices for reducing the amount of smoke from locomotives after steam is raised and engines are working, and while it is possible by great care and attention on the part of the roundhouse force to reduce the amount of smoke emitted during this period, at the same time we find no practical way to entirely eliminate all smoke while firing up locomotives at terminals.

THE BRIDGE OVER THE CULEBRA CUT AT Empire projected some months ago, is not to be built. Preliminary estimates showed that the structure would have to be put at very great height in order to clear the masts of the largest vessels which might pass through the canal. The necessary length of span and dimensions for a bridge of such a height, and the cost of the long approaches necessary to reach it, would make the structure enormously expensive. The traffic which would pass over the bridge, moreover, would be extremely small, and, inasmuch as the width of the canal where it enters the Culebra cut is only some 500 ft., the simplest and by far the cheapest method of giving transit facilities across the canal will be a ferry-boat and car transfer. As there are neither current nor waves in the canal and the distance across is extremely short, such ferry-boats could be very low powered and inexpensive.

*Report of committee presented to the annual convention of the American Railway Master Mechanics' Association, Atlantic City, N. J., June 14-18, 1911.

Power Plant of the New Transatlantic Steamship "Olympic."

The new steamship "Olympic," of the White Star Line, was launched at Belfast, Ireland, from the Harland & Wolff yard Oct. 20, 1910, and sailed on her initial voyage from Southampton to New York on June 14, 1911, arriving at New York June 21. This vessel, nearly 883 ft. long over all, is the largest now in commission—she is about 90 ft. longer than the "Mauretania"—but the keel of a still larger ship was laid at Stettin, Germany, for the Hamburg-American Line some six months ago. The first keel plate of the "Olympic" was laid in December, 1908, 20 months before she was launched.

The following table, taken from a long descriptive article in "Engineering" (London), issue of Oct. 21, 1910, shows the "Olympic's" principal dimensions:

Length over all	882 ft. 9 ins.
Length between perpendiculars	850 ft.
Breadth, extreme	92 ft.
Depth, molded	64 ft. 3 ins.
Total height from keel to navigating-bridge	104 ft.
Gross tonnage	45,000 tons
Load dfaft	34 ft. 6 ins.
Displacement at load draft	About 60,000 tons
Indicated horse-power of reciprocating engines	30,000
Shaft horse-power of turbine engine	16,000
Speed	21 knots

Her sister ship, the "Titanic," which was launched May 31, has approximately the same dimensions. It will be noted that no attempt has been made to equal or excel the high speed of the "Mauretania" and "Lusitania." The White Star liners have fuller lines than the Cunarders and have little more than three-fifths their horse-power.

Machinery.

The "Olympic" is propelled by a combination of two reciprocating steam engines and one low-pressure turbine. There are three screw propellers, and the two outer or wing propellers are driven by the reciprocating engines while the turbine, working on the exhaust steam from the main engines, drives the middle propeller shaft. The reciprocating engines are of the four-cylinder triple-expansion type taking steam at 215 lbs. per sq. in. and are run at about 75 r. p. m. The exhaust-steam turbine is of the Parsons type, designed to take steam at about 9 lbs. absolute, expanding down to 1 lb. absolute. It is run at 165 r. p. m. Further details of the ship's power plant and machinery are abstracted below from the Engineering Supplement of the London "Times."

THE MAIN ENGINES.—The high-pressure cylinder is 54 ins. in diameter, the intermediate-pressure 84 ins., and the two low-pressure each 97 ins., the stroke being 75 ins. Steam is supplied at 215 lbs. per sq. in., and is exhausted at about 9 lbs. absolute. The crank and thrust shafts are 27 ins. in diameter, bored with a 9-in. hole, the line-shaft 26¼ ins., and the tail-shaft 28½ ins., the hole in the two latter being 12 ins. To facilitate repairs, there is a loose coupling on the tail-shaft, enabling it to be withdrawn from the stern. The propellers, 23 ft. 6 ins. in diameter, have a cast-steel boss and three bronze blades.

The exhaust turbine, which is placed in a separate engine-room abaft of the reciprocating engine-room and separated from it by a watertight bulkhead, receives steam at 9 lbs. absolute and expands it down to 1 lb. absolute, the condensing plant being designed to attain a vacuum of 28½ ins. (barometer 30 ins.), with circulating water at 55° to 60° F. The rotor, built up of steel forgings, weighs about 130 tons, and has a diameter of 12 ft. The blades, ranging in length between 18 ins. and 25½ ins., are built on the segmental principle, laced on wire through the blades and distance pieces at the roots, and with binding soldered on the edge. The length between the extreme edges of the first and last ring of blades is 13 ft. 8 ins. The propeller, connected by a turbine-shaft 20½ ins. in diameter and a tail-shaft 22½ ins., each bored with a 10-in. hole, is built of solid manganese bronze, with four blades, its diameter being 16 ft. 6 ins.

CONDENSING PLANT.—There is no astern turbine, the center shaft being put out of action when the ship is being manoeuvred. In that case the steam from the reciprocating engines is sent direct to the condensers by means of change-valves which shut it off from the turbine. The condensers are of pear shape, such as has been used for some time on all ships built by Messrs. Harland and Wolff, which has the advantage of concentrating the tube surface at the point where the largest volume of steam is admitted. There are four sets of gunmetal circulating pumps, two for the port and two for the starboard condensers, with 29-in. inlet pipes, all driven by compound engines. Each condenser has two sets of air pumps of the dual type, both air and water barrels being 36 ins. in diameter, with a stroke of 21 ins. The water from each condenser passes into a feed tank, and then drains into a control tank, whence it is drawn by the hot-well pumps and discharged through a surface heater to a contact heater placed high on the engine bulkhead. The surface heater takes the exhaust from the electric engines for heating the feed, while the contact heater utilizes the exhaust from the other auxiliaries for the same purpose. The water from the contact heater gravitates to the main-feed pumps, of which there are two pairs on each side of the reciprocating engine-room. They have a diameter of 14 ins., with a stroke of 28 ins., and steam cylinders 19 ins. in diameter. Two pairs are sufficient to feed the whole of the boilers.

REFRIGERATION AND ELECTRICITY.—The refrigerating machinery, which is arranged on the port side of the reciprocating engine-room, where it is readily under the observation of the engineers, consists of two horizontal duplex carbonic acid machines, each of which combines two complete units capable of independent working, so that actually four refrigerating units are provided. Each machine has its own steam surface condenser, brass circulating pump, and air and feed pumps, and there is a duplex brass-ended water pump to serve as a stand-by. The evaporators are correspondingly divided into four units, and are placed in an insulated recess above the machines at the orlop deck level, at which level also are the brine pumps, three in number, with interchangeable connections. The brine return tanks are still higher, immediately above the evaporators. The brine circulation is on the open return system, with separate flow and return on each circuit. The circuits are of moderate length, and are interlaced in the chambers to secure even distribution of the cooling effect, even in the remote contingency of one section becoming blocked.

For generating electric energy there are four 400-KW. dynamos, arranged at tank top level in a separate watertight compartment aft of the turbine-room, between the central and the wing propeller shafts. Each is directly coupled to a 580-HP. vertical three-crank compound engine running at 325 r. p. m., the high-pressure cylinder being 17 ins. in diameter and the two low-pressure 20 ins. They receive steam at 185 lbs. per sq. in., and exhaust either into a surface heater—which is the usual sea-going condition—or into the condenser. In addition, there are two emergency 30-KW. dynamos placed in a recess off the turbine-room at saloon deck level, well above the water-line. The engines of these are similar to those of the main sets, but are of the two-crank type, and they can be furnished with steam from one of several boiler-rooms. The current, which is generated at 100 volts, is distributed on the single wire system, and is controlled from a main switchboard in the electric engine-room. Electricity is employed not only for lighting and heating, but also for driving no fewer than 75 Sirocco fans for ventilation, in addition to numerous electric cranes and winches for cargo purposes.

STEAM GENERATING PLANT.—The boilers, 29 in number, and all but five double-ended, measuring 20 ft. long by 15 ft. 9 ins. in diameter, are disposed in six watertight compartments, each of which except the forward one holds five athwartship. The five single-ended boilers, which are 11 ft. 9 ins. long, and also 15 ft. 9 ins. in diameter, are placed in the compartment nearest the machinery space and are arranged to be available for the auxiliary machinery while the ship is in port, as well as for the general steam supply when she is at sea. Two boilers in each of two other compartments, however, have separate steam leads to the auxiliary machinery, including the electric light engines.

In regard to stoking, the coal is first shipped in a main bunker between decks immediately within the skin of the ship, and is thence distributed into bunkers arranged at stokehold level, athwart the ship. This arrangement enables each stoker to take his coal practically from the bunker door, the bunkers being situated on each side of the main bulkheads, and therefore immediately in front of the furnaces.

In each of the boiler compartments there is a large duplex pump placed in a separate room, where it is protected from dust. These pumps work the ash-ejectors, circulate or feed the boilers as required, and can also be used for pumping the bilges, except in three of the compartments where there are independent ballast pumps.

FREIGHT TRANSPORTATION WITHIN CITIES must be furnished by railway companies, according to a decision of the State Railroad Commission of Ohio. This decision reverses the practice of most railways, which have hitherto refused to make reasonable rates for freight service to and from points within a city's limits. Under this decision such service must be rendered by the railways if desired and is subject to rate regulation. The case in which the question was tested was brought by the Akron Gravel & Sand Co. against the Baltimore & Ohio and Erie railways.

Investigation of the Martins Creek Accident on the Pennsylvania R. R. by the New Jersey Public Utility Commission.

The accident April 29 near Martins Creek Station, N. J., on the Belvidere division of the Pennsylvania R. R., has been investigated jointly by the Interstate Commerce Commission and the newly created Board of Public Utility Commissioners of New Jersey. This accident, of which a brief account was published in our issue of May 4, p. 549, caused the death of twelve persons and the injury of 101 others. The train wrecked was a Delaware, Lackawanna & Western R. R. excursion train bound from Utica, N. Y., to Washington, D. C. It was derailed at a curve where repairs were being made to the track.

The wreckage was consumed by a rapidly spreading fire which was fed by escaping gas from the tanks of the car lighting system. Some of the cars were lighted by acetylene and it was rumored that the derailment itself was caused by the explosion of one of the acetylene tanks. The report of the Public Utility Commission, however, with which the Interstate Commerce Commission concurs, exonerates the acetylene system from all direct blame for the wreck, which is ascribed to the condition of the track. An abstract of the Public Utility Commission's report follows:

The derailed train was the second section of passenger train No. 573 and consisted of Pennsylvania engine No. 3169, Delaware, Lackawanna & Western combination car No. 706, Delaware, Lackawanna & Western coaches Nos. 84, 100 and 85, and Delaware, Lackawanna & Western dining car No 458, in the order named. All of the cars were of wooden construction with vestibules and steel platforms. Coach No. 100 was lighted with acetylene gas and dining car No. 458 was lighted with acetylene gas and equipped with an axle-generator for electric light. The other cars were lighted with Pintsch gas.

The train was enroute from Utica, N. Y., to Washington, D. C., with 168 passengers and two tourist agents; it left Manunka Chunk at 2.40 p. m., and was derailed at about 2.56 p. m. The engineman, conductor and baggageman received injuries from which they soon died, and the fireman was seriously injured.

The derailment was immediately followed by fire, caused by the ignition of gas, evidently from a puncture in the gas tank under the third coach (No. 100), as well as from the escaping gas from the gas tanks under the other cars, which had their connections broken and permitted gas to escape. All cars were totally consumed by fire. The gas tank under the dining car exploded several hours after the wreck, due to heat from the burning cars.

On the morning of April 29, acting under the instructions of the Supervisor of the Belvidere division of the Pennsylvania R. R., the section foreman with a force of 17 men was engaged in throwing, realining and surfacing the curve south of the Ferry Crossing, about eight-tenths of a mile south of Martins Creek station, to the line stakes that had been set some months before. The track at this point runs almost directly north and south, with about 0.5% grade toward the south. The curve is about 2½° and has a superelevation of about 5 ins. for the east or outside rail. The track is laid with 85-lb. standard steel rails, which have been in service nine years, and showed from ⅛-in. to ¼-in. wear on the curve north of point of derailment. There were from one to two bad ties in the track for each rail length and tie plates were used on each rail. Track is ballasted with gravel and cinders.

The required work was to throw or shift the track from about two to nine inches, at different points, for a distance of about 1,000 ft. The ballast was removed from the ends of the ties on the inside side of the curve, for the distance necessary to permit of the throw or shift of the track to the proper alinement. After throwing this track, by the use of bars and by easy stages of from one to two inches at a time, to the proper alinement, as indicated by the line stakes, the ends of the ties were tamped up with shovels. The section foreman then lined up and surfaced the inside rail, and had partially lined up and surfaced the outside rail.

The track, both north and south of, as well as at the point of derailment, had been thrown from two to nine inches on the day of the accident. Track jacks were used at different places on the curve in raising track to proper level. At the time of the accident the men were engaged in filling up the center of the track and tamping up under the ties with shovels at a point just immediately north of the place where the derailment occurred. The track gage was not used at any time in doing this work, but the level board was used for the purpose of arranging proper superelevation and the necessary run-off leading to the same. During the forenoon, flagmen were used to protect this track in both directions, and

after noon hour a flagman was used to protect against trains from the north until about 1 p. m., the time of the arrival of the first section of No. 573, after which time no flagman was used. Three trains passed over this track between 1 p. m. and the time of the wreck. No one of these, however, was running at as high a speed as the wrecked train.

Eye-witnesses of the accident say that the cars were derailed first. Some testified there was an explosion following the crash of derailment; others that the crash of derailment was immediately followed by an explosion. Others say that the crash of derailment was all that they heard or saw. All agree as to the almost immediate presence of fire. Testimony as to the condition of the gas-tank equipment disproves any theory of gas explosion, on account of the fact that the gas tank under car No. 100, the one supposed to have exploded, had been punctured by some outside agency.

Two committees of experts, selected by the Pennsylvania R. R. Co., made careful inquiry and investigation as to the cause of the accident and agree as to it being a derailment of the forward trucks of the tender, and agree practically as to where these trucks left the rail. They disagree as to the cause of the derailment. One committee reported the derailment as evidently caused by a combination of uneven and irregular track, the high speed of the wrecked train while passing over the track, and the probable failure of the section men to have proper superelevation on the curve, together with suitable run-off leading to the same, and sufficient ballast against ends of ties on high side of curve. The other committee reported that track condition was such as would warrant them expressing the opinion that it was not the cause of the derailment.

An outside expert,* who was on the ground May 2, gathering data and making measurements as to the condition of the track both at the point of the accident and at the curve just north of the accident, expresses the opinion that the cause of the derailment was the uneven and irregular condition of the track and the failure to have proper superelevation on the curve and run-off leading to the same, causing the forward trucks of the tender to mount the rail, followed by the derailment of the other cars in the train.

The track, being in loose condition, each train that passed over, prior to the accident, caused it to settle to such an extent that it became uneven and irregular and, in the opinion of Inspector McKelvey, this caused the driving wheels of the wrecked engine to mount the outside rail, throwing the rails across the track and thus letting the entire train, with the exception of rear trucks of the dining car, off almost simultaneously. This theory is strengthened by the fact that no one of the cars was telescoped. The train, running at a speed of about 50 mi. per hr., was thrown down an embankment on the east side and outside of the curve, the engine, tender and first car of the train turning over on their sides, the remaining cars standing nearly upright.

The evidence shows that no throwing or alining was done after the first section of No. 573 passed; but work of surfacing, tamping and filling between the ties was being done continuously until the arrival of the second section. The Board, under these conditions, concurs in the opinion of Inspector McKelvey that the section foreman erred in judgment in not having the track in proper condition for the safe passage of second 573, which was running at high speed. Under the circumstances he should have protected the same by a flag.

CONCLUSIONS.—It is the conclusion of the Board and of the Interstate Commerce Commission, from the evidence in this case, that the derailment was caused by an uneven, irregular and insecure condition of track, which would not permit a train to pass over it in safety, at a speed of from 50 to 60 mi. per hr., the rate at which this train was running.

It is also concluded that this piece of track should have been protected by flag, until the work was completed; that is, until the elevation of the high rail had been carried around the curve and properly run off at the same point where the surfacing had been run off on the lower rail, and ballast replaced against the ends of the ties on the high side of the curve.

The rule, as interpreted by an official of the Pennsylvania R. R. Co., does not require flag protection during work of this character, and we believe such rule should be so amended as to leave no doubt as to the requirements of flag protection to all trains when the track is being shifted, realined or thrown, or where such similar insecure conditions of track exist.

The fact that the cars in this train were of wooden construction, and that the lighting system used was gas, are evidently responsible for the great loss of life and the total destruction of the train by fire. Had the cars been of steel construction, or had electricity been used as the lighting system, it is certain the loss of life would not have been so great, since many of those killed could have been rescued except for the rapid spread of the flames.

*John I. Reigel, of Scranton, Pa. He was gathering material for a book on train accidents, according to press reports.—Ed.

A FOREST FIRE IN JAPAN in Hokkaido province in the latter half of May is reported to have caused a timber loss estimated at $5,000,000. A number of buildings were destroyed.

WORK IN THE "MAINE" COFFERDAM in Havana Harbor has progressed very favorably to date. Pumping has been carried out in stages of 5 ft., each level being held for several days, and on June 20 the water had been lowered 15 ft. Leakage has not given any great amount of difficulty. Gen. Bixby, who made an inspection visit, is reported as expressing his satisfaction at the good performance of the cofferdam.

A DISASTROUS AEROPLANE RACE from Paris to London and return was started on June 18, there being 50 contestants, 38 civilians and 12 officers of the French Army assigned to the contest as military duty. The start was made at the aviation field near Vincennes and three men, Capt. Princetau, Lendron, and Le Martin were killed soon after the starting. The first two were burned to death following the explosion of their engines or fuel tanks. The third had trouble with his steering gear and was dashed into a clump of trees and crushed by his engine. Eighteen contestants covered the first stage, to Liege, Belgium.

THE CAUSE OF THE FLOOR COLLAPSE, which resulted in the deaths of four workmen on March 9, in an apartment house in the course of erection at 10 East 87th St., New York City, was found by the coroner's inquest to be the premature removal of the forms on the ground floor. These forms were removed two days before the accident to make place for a hoisting engine and boiler. The dimensions of the floor bay immediately above were 17 ft. 9½ ins. × 25 ft. 11½ ins., and floor was built of the two-way concrete-and-tile construction known as the Burchartz System, described in Engineering News, June 16, 1910. The finding of the coroner's jury was substantially the same as the cause surmised in the description of the accident which was given in Engineering News of March 16, 1911. The eight floors had been carried up in about two weeks. In each of the large bays some twenty-odd posts had been placed to carry the weight of the floor above. These rested upon planks with the idea of transmitting the loads to the steel frame. After the posts on the ground floor were removed, part of the top floor and the roof were added to the loads already on the posts. The first floor had been further weakened by cutting a 3-ft. hole in the center of it for the smoke stack of the boiler. The coroner fixed the responsibility on the superintendent for the sub-contractor on concrete work, who had ordered the forms removed.

THE NEW JERSEY PUBLIC-UTILITY COMMISSION on June 3 decided that the free transportation, on behalf of a municipality without discrimination, of policemen, firemen, and health-board inspectors was not regarded as a violation of the utility law of 1911 which forbids the free transportation of "public officials."

THE ST. LOUIS MUNICIPAL BRIDGE over the Mississippi River is progressing. About half of the piling for the falsework of the east span has been driven, and the hoisting towers for lifting the steel from the material track to the track on the bridge floor are nearly completed. It is expected that erection of the steel will be commenced late in July.

THE CHICAGO MUNICIPAL HARBOR project has been advanced a step by the action of Governor Deneen in signing the bill which authorizes the city to proceed with the building of an outer or lake-front harbor at any part of the lake front as soon as the city is able to provide the necessary funds to carry out the work. This bill goes into effect on July 1, and in the meantime a council committee is considering the question of location and plans. The best advantages appear to be afforded by the proposed location immediately north of the mouth of the river, where piers would be built projecting eastward from the shore, or southward from a main pier and breakwater marking the north limit of the harbor. Another bill was introduced in the legislature to empower the Sanitary District of Chicago to build an outer harbor in the event of the city being unable to raise the necessary funds for the work, but this was killed in the House. A bill for an inner harbor on Lake Calumet was passed by the legislature but was vetoed by the Governor on the grounds (1) that the location was fixed too definitely (in advance of engineering investigation), (2) that it would be difficult of access, being 4½ miles inland and must be reached by a channel crossed by several railways; (3) that the project would delay the carrying out of the Sag drainage channel to the Main Drainage Canal; (4) that the cost is variously estimated at $7,000,000 to $18,000,000, and (5) that some of the leading engineers of the state are of opinion that an outer harbor rather than an inner harbor is needed for the commerce of the city of Chicago.

A PATENT DECISION ON EDISON GIANT ROLLS, recently handed down by the U. S. Circuit Court of the western district of New York (Judge Hazel), in an infringement suit brought against the Allis-Chalmers Co. by the owners of the patents sustains the validity of the patents for these rolls. The Edison giant rolls, as used in the works of the Edison Portland Cement Co. (Eng. News, Dec. 24, 1903, pp. 555-559) and the new plant of the Tomkins Cove Stone Co. (Eng. News, Jan. 12, 1911, pp. 29-33), are capable of breaking stones weighing 5 to 20 tons, and reduce them to 6 or 7-in. size. They consist of a pair of large rolls, 5 to 6 ft. diameter, set in fixed bearings, and driven by belt at high speed, whose surface is formed with rounded projections or knobs; the impact of these knobs breaks the rock. The decision of Judge Hazel finds that the successful construction of these rolls involved meritorious and patentable novelty, notwithstanding the prior existence of crushing rolls with irregular surfaces. Mr. T. C. Martin, one of Edison's biographers, has prepared an abstract of the decision. The following passage exhibits the nature of deciding argument:

> A number of patents for crushers having rollers are claimed by defendants to anticipate and limit the claims in controversy, but such patents are inapplicable. To bring together and adapt in dimensions, iron rollers of such large proportions enclosed in a frame and providing means for periodically storing kinetic energy and periodically expending it as described in the specifications, was invention of the highest merit. It was not simply a question of changing the proportion, size or shape of the rolls. New and novel additions in crushing apparatus were made. The prior crushing or pressing rolls contained no helpful suggestions to the patentee as to the manner of using kinetic energy to instantaneously fracture heavy rock. Although the prior art shows crushing rolls with irregular surfaces, yet such rolls were geared together and were not driven by a belt in opposite directions. They were incapable of delivering blows to powerful rock masses. Indeed there is a total absence in the prior art of the use of kinetic energy to secure the hammering action necessary to break such heavy material as contemplated by Edison's invention. . . . In the prior art there is not disclosed any method or apparatus for breaking rock by the medium of crushing rolls which are provided with knobs or projections and are driven by belting. They were provided in most instances with teeth or projections on the rolls which were geared together and their function was to compress, pinch or pick the material to separate the particles. The driving agent apparently performed the work of crushing the material while in the patents under consideration there is a distinct departure, the material being wholly crushed or broken by the energy of the knobs on the rolls. Although some of the separate elements of the claims in controversy were old and are found in the prior apparatuses, yet such old elements had never before been assembled or combined to use power stored in the rolls to break or crush rock nor prior to the inventions in suit had such rock been broken or crushed by hammer blows from projections on the rolls driven by belt and rotating in opposite directions. . . . It is not enough to select separate elements from different devices and then without making any patentable change or improvement insist, as do the defendants, that the patented structure might have been similarly constructed. The claims are entitled to such a fair construction as will preserve to the inventor the fruits of his discovery. . . .
>
> The defendants' rolls in operation are substantially the same as those of complainant, having a like capacity for crushing rock; they use the kinetic energy to break the material periodically dumped upon the rolls and in their operations perform the functions of the patents in suit and achieve the same result. The method patent describes the mode of treatment of the rock by which it may be shattered and the series of steps to be taken in the transforming process.
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> The combination of elements by which the splendid results of breaking rock by blows due to the use of kinetic energy were attained undoubtedly involves the exercise of invention as distinguished from mechanical skill. The prior art neither suggested the patentee's method nor the apparatus by which the work could be done.

AN EXTRAORDINARY LARGE CONTRACT for harbor works has been let by the Argentine Government for the construction of the new port works at Buenos Aires, to Messrs. C. H. Walker & Co., Ltd., of London, Eng. The amount involved is nearly $27,000,000 and includes the reclamation of over 200 acres of land, the construction of four new docks, with quays extending over 15,000 lin. ft. and warehouses covering about 100 acres of floor space.

The reinforced-concrete portion of the work, to be executed by Messrs. Edmond Coignet, Ltd., under their system of construction, includes 14 large warehouses, 20 sheds, 80 subways connecting the buildings, and a large number of grain tanks, in all about 168,000 cu. yds. of concrete and 20,000 tons of steel.

The engineers for the project are Messrs. Livesey, Son & Henderson.

A LARGE ROPE SHEAVE for power transmission has recently been made for use in the Pittsburg Plate Glass Co.'s plant at Forge City, Pa. It is 8 ft. in diameter with a face 16 ft. 10 ins. wide and weighs complete 66,750 lbs. The bore of the hubs is 24 ins. The sheave is made in four sections, each of which is a complete pulley 8 ft. in diameter by about 4 ft. long. The sections are bolted together through flanges.

The sheave has grooves for 72 wraps of 2-in. rope, designed to transmit 4,000 HP. at 187 r. p. m. It is mounted on a 24-in. shaft (reduced to 20 ins. in diameter in the bearings) which is hollow throughout its length of 28 ft. 6 ins. The hole through the shaft is 14 ins. in diameter. At each end is a forged steel

flange, 30 ins. in diameter by 2½ ins. thick, which corresponds with the flange couplings on the adjacent section of the driven shaft. The sheave shaft complete with its two flanges weighs 24,375 lbs. The load on the sheave-shaft bearings is therefore more than 45 tons apart from the pull on the rope. Two specially designed ring-oiling bearings are provided, each 56 ins. long, one on each side of the sheave.

The sheave and its equipment was made by the Dodge Manufacturing Co., of Mishawaka, Ind.

OZONIZED AIR will be used for ventilating the tube of the Central London Ry., London's second oldest underground railway. Each of 14 stations on the line will be equipped with electric ozone generators with prefilters, etc. In all about 3,000,000 cu. ft. of air with 1 part ozone in 1,000,000, will be filtered and ozonized daily—one-half being introduced at the stations and the rest along the line of the tube.

Personals.

Mr. Arthur W. Byron, Assistant Master Mechanic of the Pennsylvania R. R., at Olean, N. Y., has been promoted to Master Mechanic at Buffalo, N. Y.

Mr. H. J. Freyn, M. Am. Soc. M. E., formerly Assistant Engineer of Construction with the Illinois Steel Co., South Works, South Chicago, Ill., has accepted a similar position with the Allis-Chalmers Co., of Milwaukee, Wis.

Mr. J. M. Burrows, Assistant Engineer in charge of street construction at Des Moines, Iowa, has resigned to become Superintendent of Construction at Des Moines for the Mayer Bros. Construction Co., of Erie, Pa. Mr. George Dobson, Bridge Engineer, was appointed to succeed Mr. Burrows.

Mr. Samuel D. Foster, of Pittsburg, Pa., has been appointed Chief Engineer of the State Highway Department of Pennsylvania under Mr. E. M. Bigelow, M. Am. Soc. C. E., Commissioner. Mr. Foster is at present in charge of the roads of Allegheny Co. His salary will be $7,000 per annum.

Mr. Preston K. Yates, M. Am. Soc. C. E., formerly Chief Engineer of the Tomkins Cove Stone Co., who had charge of the erection of the plant at Tomkins Cove, N. Y., recently described in Engineering News, has opened an office at 50 Church St., New York City, for the practice of general engineering.

Mr. Fred T. Barcroft, M. Am. Soc. C. E., of Detroit, Mich. has been appointed a member of the City Plan and Improvement Commission of Detroit. Mr. Barcroft has also been selected by the city of Toledo, Ohio, to assist Mr. E. W. Bemis in placing a valuation on the property of the Toledo Railway & Light Co.

Mr. Arthur H. Blanchard, M. Am. Soc. C. E., Associate Professor of Civil Engineering at Brown University, Providence, R. I., has resigned to accept the appointment of Professor of Highway Engineering at Columbia University, New York City. Mr. Blanchard will have charge of the graduate courses in highway engineering which are to be established in the fall.

Maj. Edgar Jadwin, Corps of Engineers, U. S. A., Resident Engineer on the Panama Canal at Cristobal, and Capt. Horton W. Stickle, Corps of Engineers, U. S. A., Assistant Engineer at Cristobal, are to be transferred from the work on the Canal as soon as their services can be spared. Maj. Jadwin will report to the Chief of Engineers at Washington and Capt. Stickle will relieve the engineer officer stationed at Wilmington, N. C.

Messrs. Rudolph Hering and George W. Fuller, M's. Am. Soc. C. E., consulting hydraulic and sanitary engineers of New York City, have announced the termination of their ten-year partnership agreement under the firm name of Hering & Fuller, excepting as to certain existing engagements, which will be completed by the firm. Hereafter they will conduct independent offices at their present address, 170 Broadway.

Messrs. Rudolph Hering and John H. Gregory, M's. Am. Soc. C. E., have formed a partnership as consulting engineers and sanitary experts. Mr. Gregory is a graduate of Massachusetts Institute of Technology, class of 1895, and has been up to the present Engineer for the Metropolitan Sewerage Commission of New York.

Mr. George W. Fuller, M. Am. Soc. C. E., has associated with him as partners Messrs. James W. Armstrong, James C. Harding and James R. McClintock, all formerly of the staff of Hering & Fuller, New York City. Mr. Armstrong was for a number of years in the City Engineering Department of New Orleans, La., in charge of sewerage and water-works design, and has recently had immediate charge of the design of the water-purification plants at Grand Rapids, Mich., Minneapolis, Minn., and Montreal, Que. Mr. Harding was Assistant City Engineer of Pittsfield, Mass., and during the last four years has been connected with the sewage disposal works at Atlanta, Ga., Batavia and Rome, N. Y., and other places. Mr. McClintock was Resident Engineer of the water filtration plant at Burlington, Vt., and is at present in charge of water-works and sewerage improvements at Clarksburg, W. Va.

Mr. Charles D. Jameson, M. Am. Soc. C. E., has been selected by the Red Cross Society to aid the Chinese Government in controlling the river Whwai, in Central China, whose periodical floods have much to do with causing the terrible famines in that district. Mr. Jameson is a native of Bangor, Me., and was at one time at the head of the department of civil engineering at Iowa University. He has been engaged in engineering work in China for many years and was until recently Supervising Engineer and Architect to the Imperial Chinese Board of Foreign Affairs at Pekin, China.

Mr. George S. Rice, M. Am. Inst. M. E., Chief Coal Mining Engineer of the U. S. Bureau of Mines, sailed from New York on June 17 for Europe, where he will visit England, Belgium, France and Germany to study methods employed in the prevention of mine accidents. Mr. Price heads a party of American mining engineers, sent at the request of the Bureau of Mines by their several companies to study European methods of accident prevention. The party includes Messrs. John Bart, of the Berwind-White Co., Windber, Pa.; A. B. Jessup, M. Am. Inst. M. E., of the Lehigh Valley Coal Co., Wilkes-Barre, Pa.; Erskin Ramsey, M. Am. Inst. M. E., of the Pratt Coal Co., Birmingham, Ala., and H. M. Warren, of the Delaware, Lackawanna & Western Co., Scranton, Pa. The members of the committee will make separate reports to their respective companies and a general report to the Bureau of Mines.

Obituary.

Sylvester T. Smith, a former General Manager of the Union Pacific and Denver & Rio Grande Rys., died in Chicago, Ill., on June 18, at the age of 72 years.

E. M. Kenly, M. Am. Soc. C. E., Vice-President and Chief Engineer of the Yakima Valley Transportation Co., North Yakima, Wash., died on June 10, after a brief illness.

G. C. Utter, a civil engineer and prominent resident of Edgemont, So. Dak., died at Friendship, N. Y., on May 23. He was a pioneer resident and ranch owner of South Dakota and was the builder of many roads and highway bridges.

Samuel Melvin, a retired contractor, died in Philadelphia, Pa., on June 13. He was born in Lancaster Co., Pa., in 1830. He was an early operator in the oil industry and built up a large business in well drilling, both for oil and for artesian wells. He built the first water-works at Atlantic City, N. J., and was contractor for the removal of Smith Island in the Delaware River.

Jacob Roth, formerly Assistant Engineer of the Bureau of Buildings, Borough of Brooklyn, New York City, died on June 18, aged 56 years. He was born in Germany and educated at the Academy of Fine Arts in Vienna. He studied later in London and Paris. After coming to this country he was employed for a number of years in the engineering department of the Pennsylvania R. R. For the past year Mr. Roth had traveled abroad for his health.

Capt. James W. Hinckley, formerly an instructor in mathematics at the U. S. Military Academy at West Point, N. Y., died in Poughkeepsie, N. Y., on June 19, aged 40 years. He was graduated from the Military Academy in 1896. He was retired in 1905 and had since been actively engaged in many industries centering around Poughkeepsie. He was President of the Poughkeepsie City & Wappingers Falls Electric Ry. Co., and an officer and director in many other enterprises.

Robert S. Furber, Assistant Civil Engineer, U. S. N., died on June 16, in the Naval Hospital in Brooklyn, N. Y. He had been ill but a short time and died while undergoing an operation for appendicitis. He was 28 years old and graduated from the U. S. Naval Academy at Annapolis six years ago. After serving for a time as Midshipman he was transferred to the engineering department and was sent to Rensselaer Polytechnic Institute, where he graduated in 1909. Since then he had been stationed at the New York Navy Yard.

Rear-Admiral Cipriano Andrade, U. S. N., retired, died in South Norwalk, Conn., on June 19. He was born in Tampico, Mex., on Sept. 1, 1840. He was educated in the public schools of Philadelphia, Pa., and studied engineering at the Franklin Institute of that city. He was appointed Third Assistant Engineer in the U. S. Navy in 1861. He saw active service on various ships throughout the Civil War, becoming First Assistant Engineer in 1865. He was also in active engineering work during the Spanish War in 1898. He was retired in 1901 with the rank of Rear-Admiral.

Col. Charles W. Larned, U. S. A., Dean of the United States Military Academy at West Point, N. Y., died recently at a private sanitarium in that town. He was born in New York City on March 9, 1850, and graduated from the U. S. Military Academy in 1870. After serving a few years in the West against the Indians, he was detailed to the Academy as Professor of Technical and Military Graphics and Applied Geometry, which position he has since held continuously. He was a member of the Architectural League of New York and of several clubs and societies.

Engineering Societies.

COMING MEETINGS.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
June 21-24. Semi-annual meeting at Chicago, Ill. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 26-30. Annual convention at Chicago, Ill. Secy., Ralph W. Pope, 33 West 39th St., New York City.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.
June 27-29. Annual meeting at Pittsburg, Pa. Secy., H. H. Norris, Cornell University, Ithaca, N. Y.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 27-July 1. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

AMERICAN CHEMICAL SOCIETY.
June 28-July 1. Annual convention at Indianapolis, Ind. Secy., Charles L. Parsons, Durham, N. C.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
July 6-8. Semi-annual meeting at Chicago, Ill. Secy., W. W. Macon, 29 West 39th St., New York City.

OHIO ELECTRIC LIGHT ASSOCIATION.
July 25-28. Annual convention at Cedar Point, Ohio. Secy., D. L. Gaskill, Greenville, Ohio.

TRAVELING ENGINEERS' ASSOCIATION.
Aug. 29-Sept. 1. Annual convention at Chicago, Ill. Secy., W. O. Thompson, N. Y. C. Car Shops, East Buffalo, N. Y.

NEW YORK ELECTRICAL SOCIETY.—The annual meeting was held at Brighton Beach, Brooklyn, N. Y., June 15. Officers were elected as follows: President, John Bottomley; Vice-Presidents, Elmer A. Sperry, J. C. Hatzel and Dr. Emil Heuel; Secretary, George H. Guy, 29 West 39th St., New York City; Treasurer, Kinsley G. Martin. After the election Mr. T. I. Jones gave a talk on "Electrical Developments at Coney Island."

INSTITUTE OF OPERATING ENGINEERS.—A meeting was held in New York City June 17 at which the Institute was duly incorporated as an institute of learning empowered to issue certificates and diplomas. The organization hitherto has been of a temporary or tentative nature. The number of charter members is 326. The first annual meeting will be held in New York City Sept. 1, 1911, when officers will be regularly elected.

AMERICAN INSTITUTE OF MINING ENGINEERS.—About half the number of persons necessary to assure the success of the proposed arrangements for a special train from Chicago to San Francisco have already filed applications. The train is to leave Chicago Sept. 30 and will visit the Grand Canyon, Los Angeles, Santa Barbara and Del Monte, arriving in San Francisco Oct. 10. After the meeting in San Francisco, Oct. 10-17, an excursion to Japan will be made, limited to 100 members and guests. The party will spend 18 days in Japan, reaching San Francisco on the return trip Dec. 17.

Prof. John D. Irving, of New Haven, Conn., has been appointed by the Board of Directors and Council to succeed Prof. S. F. Emmons, who died recently, as a delegate to represent the Institute in the American Association for the Advancement of Science.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.—The Tuesday and Wednesday sessions of the Pittsburg meeting, June 27-29, will be held at the School of Applied Science of the Carnegie Technical Schools. Thursday's sessions will be held at Thaw Hall of the University of Pittsburg. The papers to be presented are announced as follows: "Teaching English in Technical Schools," Prof. S. C. Earle, Tufts College; "The Preparation of Written Papers in Engineering Schools," Prof. F. N. Raymond, University of Kansas; "The Use of Logarithmic Diagrams in Laboratory Work," H. A. Gehring, Department of New York State Engineer; "Highway Engineering," Prof. H. H. Blanchard, Brown University; "Balance of Courses in Chemical Engineering," Dean C. H. Benjamin, Purdue University; "Chemical Education for the Industries," Prof. J. H. James, Carnegie Technical Schools; "All-Year Sessions, Individual Instruction: Renewed Suggestions," Dean W. G. Raymond, University of Iowa; "The Architecture of Engineering Schools," Prof. J. M. White, University of Illinois; "The Wentworth Institute," A. L. Williston, Director Wentworth Institute; "An Engineering Course for Underclassmen," Profs. W. A. Hillebrand and S. B. Charters, Jr., Stanford University; "Electrical Engineering Instruction," Prof. E. B. Paine, University of Illinois; "Teaching of Scientific Shop Management, with Use of Engineering School Shops as the Laboratory," Profs. H. Wade Hibbard and H. S. Philbrick, University of Missouri; "Technical Training from the Business Man's Standpoint," E. B. Raymond, Vice-President Pittsburgh Plate Glass Co.; "Adapting Technical Graduates to the Industries," C. F. Scott and C. R. Dooley, Westinghouse Electric & Mfg Co.; "Cooperative System of Engineering Education at the University of Pittsburg," Dean F. L. Bishop, University of Pittsburg. Committee reports: "Teaching Mathematics to Engineering Students," Prof. E. V. Huntington, Harvard University; "Entrance Requirements," Prof. J. J. Flather, University of Minnesota, Chairman. Presidential address on "The Engineering Teacher and His Preparation," A. N. Talbot.